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THE MAGAZINE OF APPLIED ENGINEERING

TECHNOLOGY

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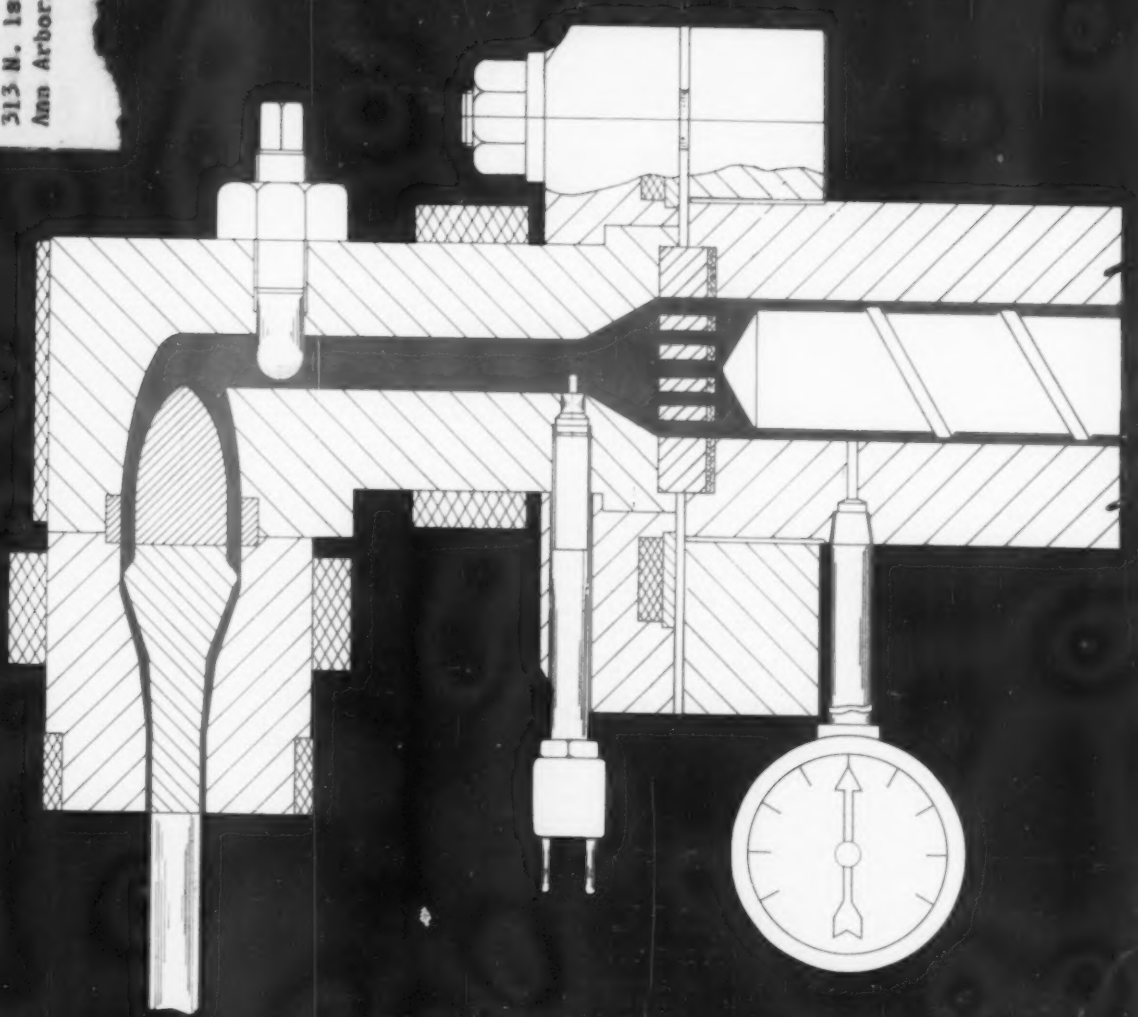

Blow Molding—II Role of the extruder

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Epon 1001-T-75	1001	Toluene	75
Epon 1001-X-75	1001	Xylene	75
Epon 1007-CT-55	1007	MIBK/Toluene (50/50)	55

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PLASTICS TECHNOLOGY

THE MAGAZINE OF APPLIED ENGINEERING

October 1960, Vol. 6, No. 10

feature articles:

ethylene copolymers ..... p. 31

by E. PRITCHARD, R. J. MARTINOVICH and P. J. BOEKE

Ethylene copolymer resins with a nominal density of 0.95 offer properties somewhat different than those of 0.96-density homopolymers. The copolymers have higher elongations and, in the higher melt index-types, offer better brittle temperatures. They also show higher stress-cracking resistance values and better long-term bearing abilities.

blow-molding II. role of the extruder ..... p. 37

by ALBERT A. KAUFMAN and ISLYN THOMAS

In extrusion blow molding, the extruder must operate continuously or intermittently, as required, to produce a suitable parison. This parison must be uniform in cross-section, be delivered at a controllable stock temperature, and be well masticated and free from surface blemishes. To do this, the extruder must have sufficient capacity to operate at a high production rate with good mixing action. Therefore, the extruder elements and instrumentation must guarantee good repeatability and maintain regular output over long periods of time.

the hotbench test method for determining gelation and fusion characteristics of plastisols ... p. 43

by J. A. GREENHOE

The hotbench test is shown to offer a simple and comprehensive means for characterizing the change of state of plastisols on heating. This test can be used to supplement or supplant existing tests now used in the plastisol industry.

the effect of molding conditions on the color of reinforced plastics moldings ..... p. 51

by THOMAS H. BEALS

Test results from experimental panels show that color of moldings can be changed visually by variations in the filler content of the molding mix, and the weight of veil. Using a high concentration of pigment reduces the visual significance of many molding variables. Varying the catalyst content, mold time, and temperature of molding should not affect the color of moldings. However, changes or poor control of the techniques used in mixing the formulations can greatly affect the color of moldings, as do also changing the type of filler used in the mixture.

engineering forums:

compression & transfer molding ..... p. 48

by PAUL E. FINA

How close your tolerances?

consultant's column ..... p. 53

by DR. S. S. STIVALA

Adhesives — part II

exploring fabrication techniques:

vinyl records ..... p. 56

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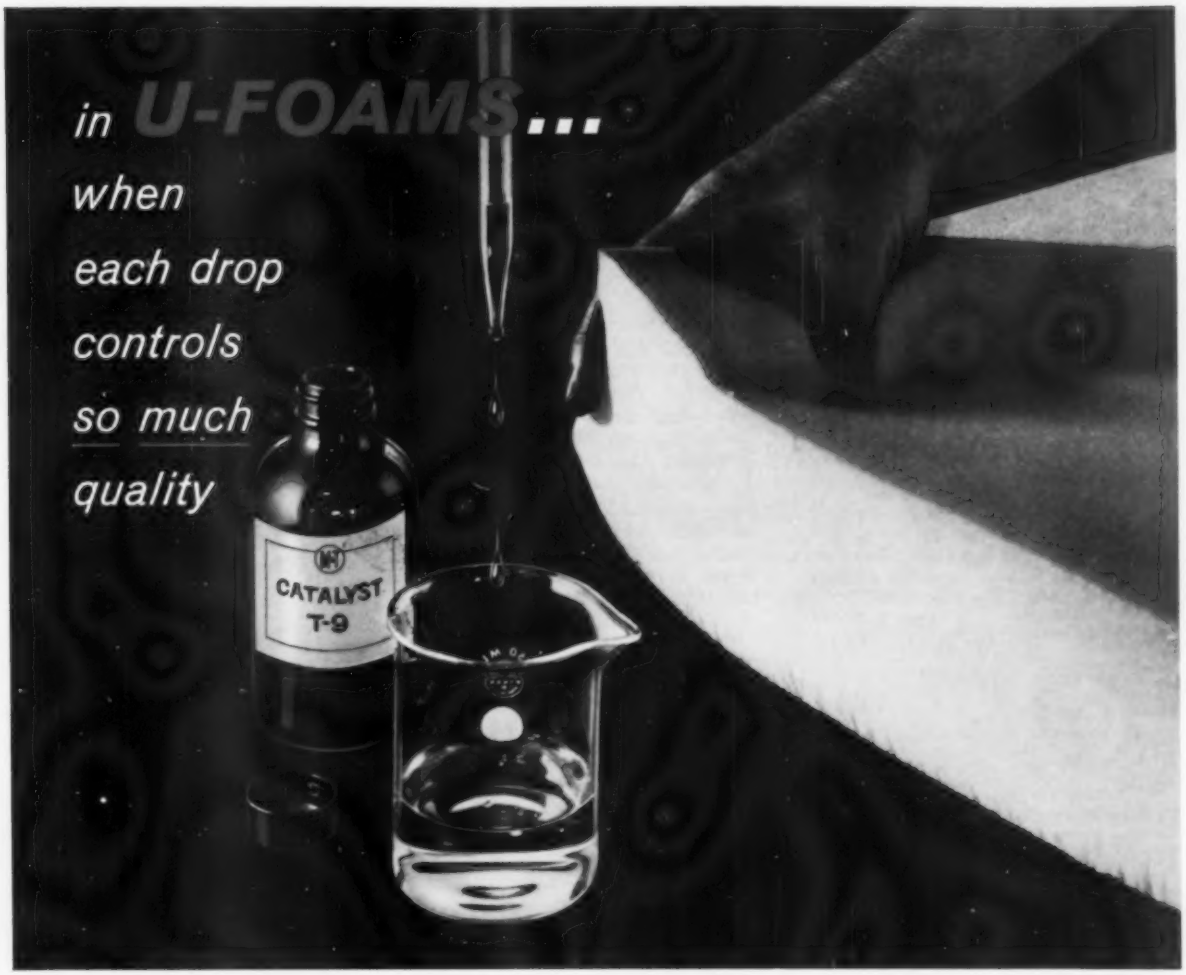

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Letters to the Editor

More on "Quick R-P Shelters"

Dear Sir:

I have noted with interest the letter by E. J. Marteka, of Tremco Mfg. Co., which you published in the "Letters to the Editors" column of your March issue (page 4). His question was "please supply me with the name of the concern who had recently formed a rigid igloo by applying a plastic to an inflated canvas hemisphere". Your reply referred him to a paper entitled "An Air Force Approach to Reinforced Plastic Shelters".

Please be advised that in addition to this reference, Atlantic Research Corp. has made such igloos by the technique described under the contract to the Quartermaster Corps. We should be happy to provide Mr. Marteka with information regarding this process.

E. R. Arnold, Appls. Engr.
Atlantic Research Corp.
Alexandria, Va.

Correction

Dear Sirs:

In the July, 1960, News of the Industry, page 55, you stated that Thermoplastic Equipment Corp. will extrude tubing. Actually, the tubing is extruded by Thermoplastic Processes, Inc., an affiliated firm. Both companies are located in Stirling, N. J.

Charles S. Herman, President
Seymour Charles Advertising Agency
Newark 2, N. J.

Injection Molding Machine Data

Dear Sirs:

The data on 1960 injection molding machines appearing in the May issue is extremely useful from a plant engineer's point of view.

Another item which could be added to the table is the weight—length x width, and height, for the following reasons.

1. Weight—floor loading and rigging requirements.

2. Length x width—plant layout information; i.e., floor space required.

3. Height—this information is required to allow the estimator to figure what has to be raised; i.e., ducts, pipe, conveyors, door ways, etc., to allow the machine to be moved into place.

In summary I might say: If two machines were being considered, and they were equal from a cycle and performance standpoint, the cost of installation and the number of square feet of production floor space would determine which machine to choose.

Please consider this as a suggestion and not criticism. I feel your magazine covers the plastic subject from a very practical standpoint.

R. L. Beesley, Plastics Tech. Service
Dow Chemical Co.
Midland, Mich.

An Author Writes

Dear Sirs:

Thank you for sending the galley proofs of my article on the Hotbench Test Method *(pages 43-47)*. The changes you have made from my manuscript should improve the article. I have corrected typographical errors and have not changed my original wording except in one instance. This corrects an error which is related to a mistake that occurred in Figure 3. A corrected Figure 3 which is in a form ready for reproduction is enclosed.

I appreciate the inconvenience this means for you, but the error was serious and should be made right. I will be grateful for your efforts to this end.

J. A. Greenhoe, Technical Service
Vinyl Resins & Compounds,
Monsanto Chemical Company, Plastics Div.,
Springfield, Mass.

(The finished article appearing in this issue incorporates all the corrections noted by Mr. Greenhoe.—Editor)

We invite letters from our readers for publication in these columns. Such letters may be of comment or criticism, requests for information, or of general interest. The only requirement is that all letters must be fully identified as to name of sender, company affiliation and address.

A letter will not be printed if publication is not desired by the sender, and hte identity of the writer will be withheld, if desired.

—The Editor

A Look-In on November

Control of Variables in Heat-Resistant Glass Reinforced Plastics. R. H. Sonneborn, A. B. Isham, and F. W. Dennen, Reinforced Plastics Laboratory, Owens-Corning Fiberglas Corp., Granville, O.

This paper summarizes the importance and effect of variables in materials and processing techniques for structural fibrous glass-reinforced plastic panels. Special attention is placed on systems employing heat-resistant resins.

•

Technical Aspects of Molding Acrylics. J. F. Moore, Technical Service Engr., Rohm & Haas Co., Philadelphia, Pa.

The injection molding of acrylics and modified acrylics generally falls into four categories: basic materials and their characteristics; gate, runner, and mold design requirements; techniques for molding part; and the test for quality. The materials are shown to be moldable over a wide range of molding conditions.

•

Surface Quality of Fiberglass-Reinforced Polyester Moldings. W. J. Diamond, Sr. Chemical Engr., The Brunswick-Balke-Collender Co., Muskegon, Mich.

The growth of the glass-reinforced plastics field in many product lines has been retarded by limitations of surface quality caused by entrapped air and inadequate resin-glass bond. Test results given are based on microscopic studies of specimens both before and after stressing. Two types of stress were used; a slow bending creep, and a fast Izod-type impact.

•

Economies Through Bulk Shipment of Plastics. D. B. Semeyn, Customer Service Engr., Plastics Technical Service, The Dow Chemical Co., Midland, Mich.

Shipment of resins in "carload" quantities provide savings to the fabricator in terms of efficiency and economy. The molder can benefit in raw material cost, warehouse space, materials-handling labor, spillage, and rejects caused by contamination of the materials.

•

Blow Molding—Economics and Limitations. Vernon Hill, Director of Plastics Development, Auto-Blow Corp., Bridgeport, Conn.

By employing a large number of molds in any one machine, a very high output can be claimed in relation to labor employment (high production of a single item must be economically feasible). Limitations of blow molding are set by the time required for cooling the material in the mold, the size and weight of the part, and the length of run that can be obtained.

IF PHENOLICS CAN DO IT **PLENCO** CAN PROVIDE IT
—AND DOES—FOR **HALLIBURTON**

HALLIBURTON 5W PLUGS have a down-to-earth job to do for oil well drillers... and do it with the help of

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PHENOLIC MOLDING COMPOUNDS

If you're going to bring in a gusher, it would be a good idea to have someone like Halliburton standing by.

Cementing the critical areas around the steel casing may be called for—for helping to protect against many down-hole hazards such as salt water flow, sulphur water, electrolysis, freshwater strata, high pressure gas, etc. And Halliburton Company, Duncan, Oklahoma, are specialists at that, leaders in service to the petroleum industry for over 35 years.

Ordinarily in most areas when cementing a well, the Halliburton 2-plug method is essential. Halliburton's type 5W bottom plug wipes the pipe clean and keeps the drilling fluid separated from the cement. The 5W top plug reduces channeling of displacement fluid through the cement. Heavy-duty cementing plugs are made of flexible molded rubber, with a 5-wiper design. The hard inner core of each plug is molded of a Plenco phenolic compound (Plenco 386).

This compound is formulated for use on parts having very thick sections. It was selected by Halliburton for this as well as for its ability to be bonded so securely to the rubber exterior that it is virtually impossible to separate the two.

Unlike Halliburton, *your* product may belong in the air rather than underground. Or it may be used on the farm, in the kitchen, on the highway. Wherever it goes, there's likely to be a Plenco general-purpose or special purpose phenolic molding compound that can make it go better, work better, look and sell better.

A conversation with our technical staff can help you "strike oil." Call on us at any time.

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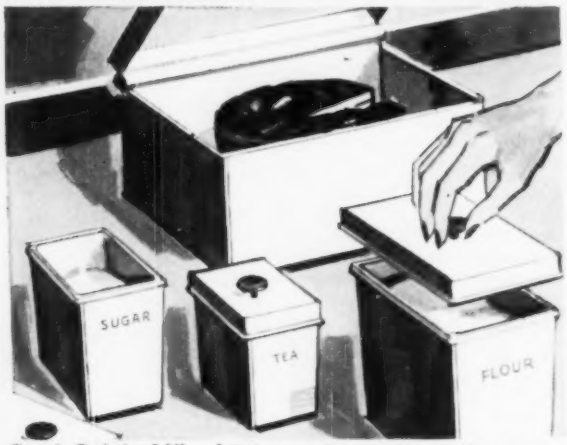
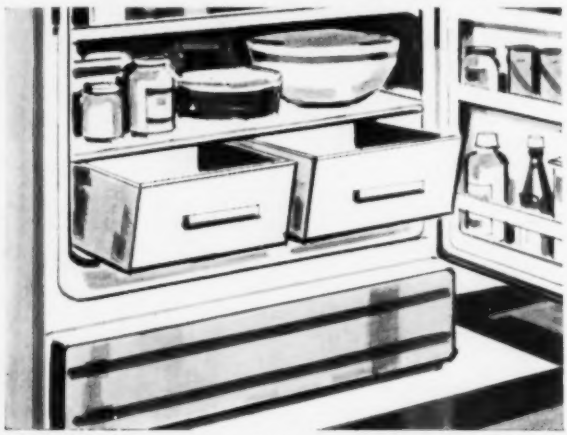
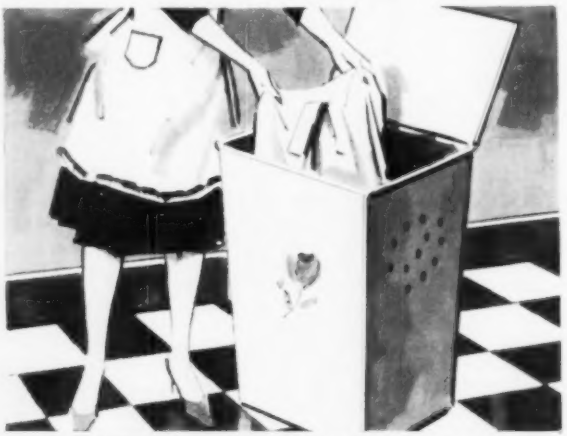


Fresh Point of View! Polypropylene is 2 to 4 times more impermeable to gases and liquids than other thermoplastics. This means freshness stays in, outside elements can't enter. This makes Escon ideal for canister sets, bread boxes and cookie jars—which can be snap-fitted or self-hinged.



Cool Item! Escon is excellent as a food crisper for several reasons. It won't absorb strong food odors and, when properly molded, has the ability to take normal cold without cracking. The design possibilities with versatile Escon are limitless, providing the opportunity to expand existing markets.



New Idea! Escon can be undercut at high speed production cycles. Such items as clothes hampers can be molded in single flat pieces of various colors, then snap-locked for assembly and hinging. This means manufacturers can ship more products in less space . . . retailers will use less storage space, too.

Escon® POLYPROPYLENE CATCHES HER

Important news for molders and designers . . . Escon polypropylene is here! It's the amazing thermoplastic ideally suited to your product needs.

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Versatile Escon is easy to work with! It can be injection and compression molded, extruded, thermoformed and heat sealed. The injection molder can start at stock temperatures of 400-450° F., for small items . . . slightly higher for larger ones. In addition, gates and runners for Escon could be of the conventional type, and normal clamp pressures would be employed when molding it. And Escon molds easily—without warpage! Because of its low density, this amazing thermoplastic resin yields more pieces per pound.

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For the designer, the high strength of Escon plus its excellent chemical and abrasion resistance allows accurate production of fine and intricate designs with high surface gloss.

And because polypropylene offers greater heat resistance than any other polyolefin, products manufactured from Escon can be readily sterilized by heat or chemical means.

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Age no longer obsoletes equipment

New concepts do. The old-time typewriter above still does the job it was designed to do. So do the control instruments in the plastics industry. And, they will continue to do a good job. But . . . do they keep pace with todays' plastic processing needs? Here are new concepts to supplement and upgrade the instrumentation you now use —

Wheelco Series 8000 Electronic Potentiometer Recorders. Self-contained, null-balance units featuring plug-in components and convenient, swing-out design.

INDICATING RECORDERS . . . Record any combination of *temperature* and *pressure* up to 24 points • Indicate temperature and pressure on separate scales • Accept as many as six limit switches — high or low limit.

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U.S.I. POLYETHYLENE NEWS

A series of advertisements for plastics and packaging executives by the makers of PETROTHENE® polyethylene resins

Packaging Notes

Molded polyethylene baby bib features a large catch-all pocket. Molded into bottom front, it traps falling food and keeps crumbs off floor. Bib washes along with dishes, is quick drying.

No-drip polyethylene pouring spout for milk bottles comes in sizes to fit quarts, halves, or gallons. Manufacturer claims it prevents spills and splashes, cleans quickly, lasts almost indefinitely. Available plain or imprinted with dairy name or logo.

New portable impulse sealer is useful for fabricating large items from polyethylene sheet, completely enclosing bulky items in polyethylene, or sealing polyethylene liners of large drums and bags. It consists of separate power pack and hand-operated sealing tongs; produces a seal 8" long, ⅛" wide. It can seal 2 pieces of up to 6 mils each.

Anti-static spray for polyethylene film works quickly and effectively on rolls, sheets, wherever static develops. Helps printers and converters of polyethylene packaging, bags, envelopes, etc. keep up high production rates—by chemically neutralizing static electricity generated by friction or atmospheric conditions. Comes in easy-to-use aerosol container.

Polyethylene packaging of brown and powdered sugar—recently introduced as "an industry first" by a California company—promises to minimize lumping and caking of these extremely moisture-sensitive products. Because polyethylene acts as a moisture barrier, it keeps the brown sugar moist, the powdered dry.

The 3-mil polyethylene bags used are 3-color flexographically printed. Size is 6½" x 13", suitable for inserting into a kitchen canister. And, once opened, the bag can be reclosed for continued freshness with a simple device offered by the company as a premium.

U.S.I. Doubles Polyethylene Capacity at Houston Plant

New Production Makes U.S.I. World's Second Largest Producer of Polyethylene Resins

A new section of U.S.I.'s polyethylene production plant at Houston, Texas, has just been started up. This new installation doubles the capacity of this plant, and establishes U.S.I. as the second largest producer of polyethylene in the world. This latest expansion brings U.S.I.'s total production capacity of PETROTHENE polyethylene resins to 300 million pounds per year.

View of U.S.I.'s polyethylene plant in Houston, Texas. With plant in Tuscola, Illinois, Company now has total production capacity of 300 million pounds per year.

Rapid Growth Since 1955

U.S.I. has grown rapidly in the polyethylene field. Its first plant with a 25 million pound annual capacity was started up at Tuscola, Illinois, in early 1955. This plant was doubled in size in 1956 and redoubled in 1957 to a capacity of 100 million pounds. In early 1959 the Houston plant was placed on-stream, with a 75 million pound per year capacity (soon increased to 100 million), and this new expansion doubles that plant capacity.

U.S.I.'s PETROTHENE resins have taken a strong lead since their introduction, especially in the film and paper coating markets. According to Vincent McCarthy, U.S.I. Director of Plastics Sales, this market position was built upon a policy of tailoring resin properties for specific applications. Within the past four months, for example, the company has developed and introduced a new produce-bag resin, a new paper coating resin, three new blow-molding resins, a new cast film resin, and two high-flow blending resins.

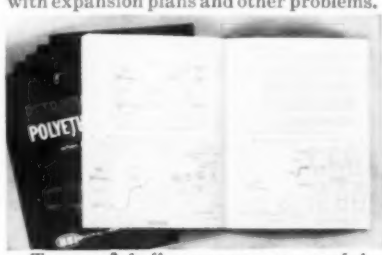
Production requirements for the new produce-bag resin are expected to make the largest single demand upon the new plant capacity. Introduced only this past April, demand for PETROTHENE 112 is already heavy, because of the unique combination of high-clarity and high-toughness it gives to produce bags and "general-purpose" film.

U.S.I. Announces New Booklet on Bulk Handling

"PETROTHENE® POLYETHYLENE . . . When to Use Bulk Handling," is a 24-page booklet prepared by U.S.I. to help resin users determine:

1. whether or not they should be buying in bulk.
2. which type of bulk packaging would best fit a particular plant's requirements.
3. which type of unloading system to choose.

Or, for processors whose plant is already equipped with a bulk materials-handling system, this booklet offers help with expansion plans and other problems.



Types of bulk conveyances used by U.S.I. to ship PETROTHENE resins are described. Graphs, tables, and calculation sheets show how net savings and payout time for capital invested in bulk handling equipment can be figured.

For copies, write to Technical Literature Dept., U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N.Y.

New Help for Blow Molders

U.S.I. has just released an 8-page Technical Data brochure entitled, "BLOW MOLDING . . . How to Obtain Highest Quality and Production Rate." It discusses mold cycle time and the more important properties of blow-molded items in detail; then, shows how each is affected by 8 variables.

This information is based on the results of an extensive research program currently being conducted by the U.S.I. Polymer Research Laboratories. Its aim is to find the resin properties and machine conditions which will result in the best product properties—at the most economical production rates. As the project continues, more reports will be issued.

For copies, write to Technical Literature Dept., U.S. Industrial Chemicals Co., 99 Park Ave., New York 16, N.Y.

MORE AND MORE... SHE REACHES FOR A POLYETHYLENE-COATED CONTAINER

with U.S.I.'s new PETROTHENE® coating resins

There's no doubt about consumer preference for dairy products, bakery goods, frozen food packaged in polyethylene-coated board containers. Now, improved coating resins developed by U.S.I. let you produce superior board for this market... at less cost and with fewer processing problems.

Grease resistance of the new resins is outstanding. For example, paper coated with PETROTHENE 205-15 (Melt Index-3, Density-0.924) passes Military Specification MIL-B-121-B for greaseproofness at lower coating weights than other resins of the same melt index and density. Adhesion, even with coatings as thin as 0.5 mil extruded at high rates, is excellent. Troublesome neck-in and curl problems are minimized... polymer build-up at the die, virtually eliminated.

PETROTHENE resin-coated board is tough, scuff-resistant... easy to print on and easy to seal over a wide temperature range. Packages made from it stay clean, smooth, sales-stimulating... with no leaking of contents... no grease wicking... no flaking off.

For complete information on these resins and technical assistance in using them, write to U.S.I.

U.S.I. INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corp.
99 Park Ave., New York 16, N. Y.
Branches in principal cities

Installation photo courtesy Lancer Industries Inc.

Shipshape pools with GLIDPOL Resins

Reinforced plastic pools by Lancer, world's largest manufacturer of plastic swimming pools, are designed for carefree enjoyment with GLIDPOL GEL-KOTE and GLIDPOL lay-up resins.

GLIDPOL GEL-KOTE, a Glidden pigmented polyester resin available in varied colors, provides smooth, porcelain-like surfaces which minimize maintenance—do not require painting. They resist the adhesion of algae and the harmful effects of sun, chemicals, heat or freezing cold as well.

GLIDPOL lay-up resins, reinforced with glass fibers, back up the GEL-KOTE to give Lancer Pools their structural strength.

From swimming pools to bathtubs, both GLIDPOL GEL-KOTE and GLIDPOL lay-up resins help make reinforced plastic products more saleable. Write for complete information on the GLIDPOL polyester resin system best suited to meet your particular requirements.

QUALITY Glidden PRODUCTS

GLIDPOL POLYESTER RESINS
The Glidden Company
INDUSTRIAL PAINT DIVISION
900 Union Commerce Building • Cleveland 14, Ohio
In Canada: The Glidden Company, Ltd., Toronto, Ontario

There's a GLIDPOL Polyester Resin system, plus Glidden Technical Service, to help you do it better, more economically, whatever your product, process or problem.

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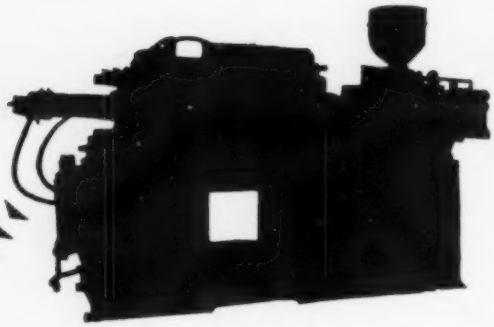

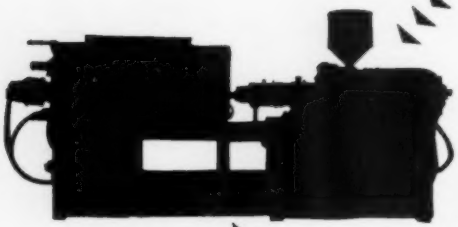

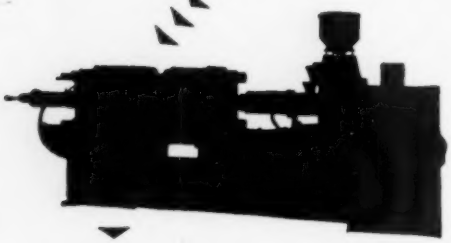

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Morflex 300 — Di Iso Octyl Adipate. Imparts excellent heat, light and viscosity stability. This ester is used alone or in combination with other plasticizers, primarily to impart superior low-temperature flexibility.

Morflex 210 — Di-2 Ethylhexyl Sebacate. Contributes to PVC compounds such properties as: outstanding low-temperature flexibility, extremely low volatility, low extraction by soapy water, good viscosity stability in plastisols, good heat and light stability, very good electrical properties and excellent drape in PVC sheeting and upholstery.

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Morflex 410 — Dioctyl Azelate. An excellent low-temperature plasticizer with good compatibility.

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Morflex P-50A — Polyester type. A 3,000-molecular weight plasticizer with outstanding gasoline and aliphatic solvent resistance.

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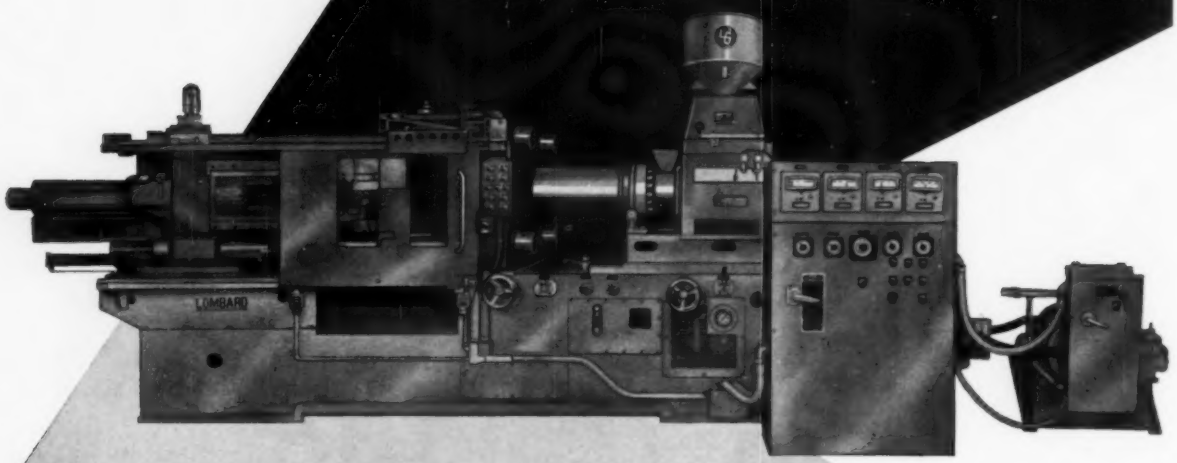

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1. Plunger advance and stuffing controls.
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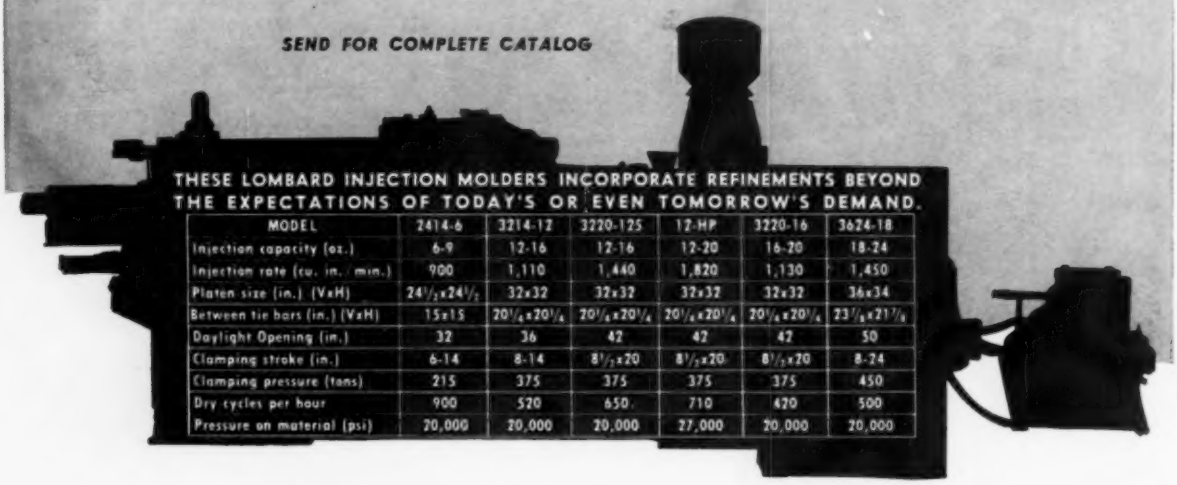


THESE LOMBARD INJECTION MOLDERS INCORPORATE REFINEMENTS BEYOND THE EXPECTATIONS OF TODAY'S OR EVEN TOMORROW'S DEMAND.

MODEL	2414-6	3214-12	3220-125	12-HP	3220-16	3624-18
Injection capacity (oz.)	6-9	12-16	12-16	12-20	16-20	18-24
Injection rate (cu. in./min.)	900	1,110	1,440	1,820	1,130	1,450
Platen size (in.) (VxH)	24½x24½	32x32	32x32	32x32	32x32	36x34
Between tie bars (in.) (VxH)	15x15	20¼x20¼	20¼x20¼	20¼x20¼	20¼x20¼	23⅞x21⅞
Daylight Opening (in.)	32	36	42	42	42	50
Clamping stroke (in.)	6-14	8-14	8½x20	8½x20	8½x20	8-24
Clamping pressure (tons)	215	375	375	375	375	450
Dry cycles per hour	900	520	650	710	420	500
Pressure on material (psi)	20,000	20,000	20,000	27,000	20,000	20,000

INJECTION MOLDING DIVISION

LOMBARD GOVERNOR CORPORATION

Ashland, Massachusetts

DOW Plastiatrics
DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

TEMPERATURE AND PHYSICAL STRUCTURE DICTATE PLASTICS' WATER VAPOR TRANSMISSION

As with gas permeability, water vapor transmission rate (WVTR) through a plastic barrier is determined by several factors. The most important of these are temperature and composition of the barrier. When the plastic is partially crystalline, the degree of crystallinity also has an important influence on this property.

Water vapor permeability is a function of the diffusion rate and solubility of water vapor in the barrier material. Water vapor apparently permeates by dissolving into the plastic at the incoming surface, establishing a concentration gradient for further penetration. Under the influence of this gradient, the dissolved water vapor diffuses through the plastic superficially in accordance with Fick's Law of diffusion. At the outgoing surface, the penetrant evaporates. Diffusion within the plastic is considered to be the rate-determining factor.

In the case of water molecules diffusing through a hydrophobic polymer, only small concentrations of water will prevail within the polymer. It is expected that Henry's Law will be obeyed and, since the polymer is swollen negligibly by the absorbed water, the diffusion coefficient in Fick's Law should be independent of concentration. In such an ideal system, the permeability coefficient characterizes the transport of water vapor through the polymer. By definition, the permeability coefficient is equal to the product of the solubility coefficient and the diffusion coefficient.

$P = DS$, where:

P = Permeability Coefficient
D = Diffusion Coefficient
S = Solubility Coefficient

An increase in temperature increases the water vapor permeability. Also, the transmission rate varies exponentially with the reciprocal of the absolute temperature ($\log \bar{p}$ vs. $\frac{1}{x}$). The linear relationship holds between 35° and 97° C.

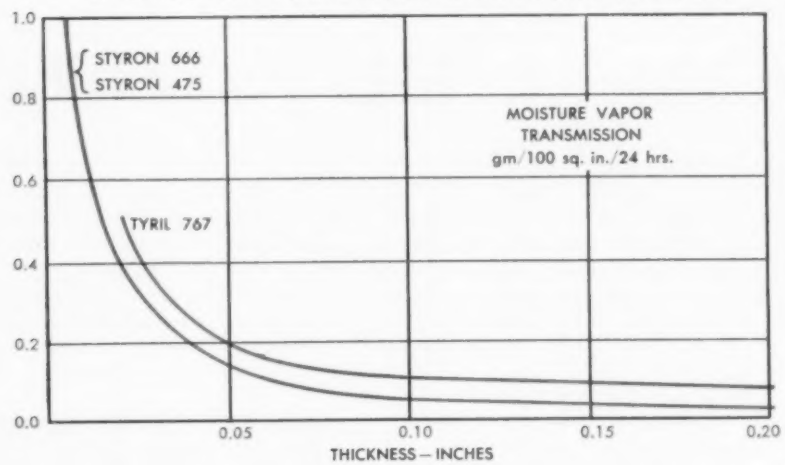
Permeability is directly affected by the molecular structure of the plastic barrier. For example, with partially crystalline polymers such as polyethylene, water vapor transmission is believed to occur almost entirely through the amorphous phase, with little or no transmission through the crystalline phase. Therefore, the amount of penetrant absorbed appears to be in direct proportion to the amorphous material present in the polymer.

One explanation of the negligible degree of vapor permeation through the crystalline phase of the polymer is that there is no free volume to accommodate the water molecule.

In the case of most plastic materials, the water vapor transmission rate is treated as an activated rate process, with the assumption that the water molecules diffuse as holes are formed in the polymer due to segmental motion of the polymer chains. However, in the case of polystyrene it is generally assumed that moisture transport proceeds along submicroscopic cracks or channels, not by the usual mechanism which apparently holds for most other materials. As with all plastic materials having low water absorption, the WVTR for polystyrene is not sensitive to the humidity at which the tests are made.

This study on water vapor permeability is one of a continuing series of Plastiatrics Studies being made by Dow Plastic Technical Service Engineers. For detailed information on this study, and on others covering every area of interest to plastics designers and engineers, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1803DT10.

CURVES OF WVTR VS. BARRIER THICKNESS FOR THREE DOW PLASTICS.
ASTM METHOD E 96-53T PROCEDURE E
TEMPERATURE 100°F RELATIVE HUMIDITY: 0% IN DISH, 95% OUTSIDE DISH



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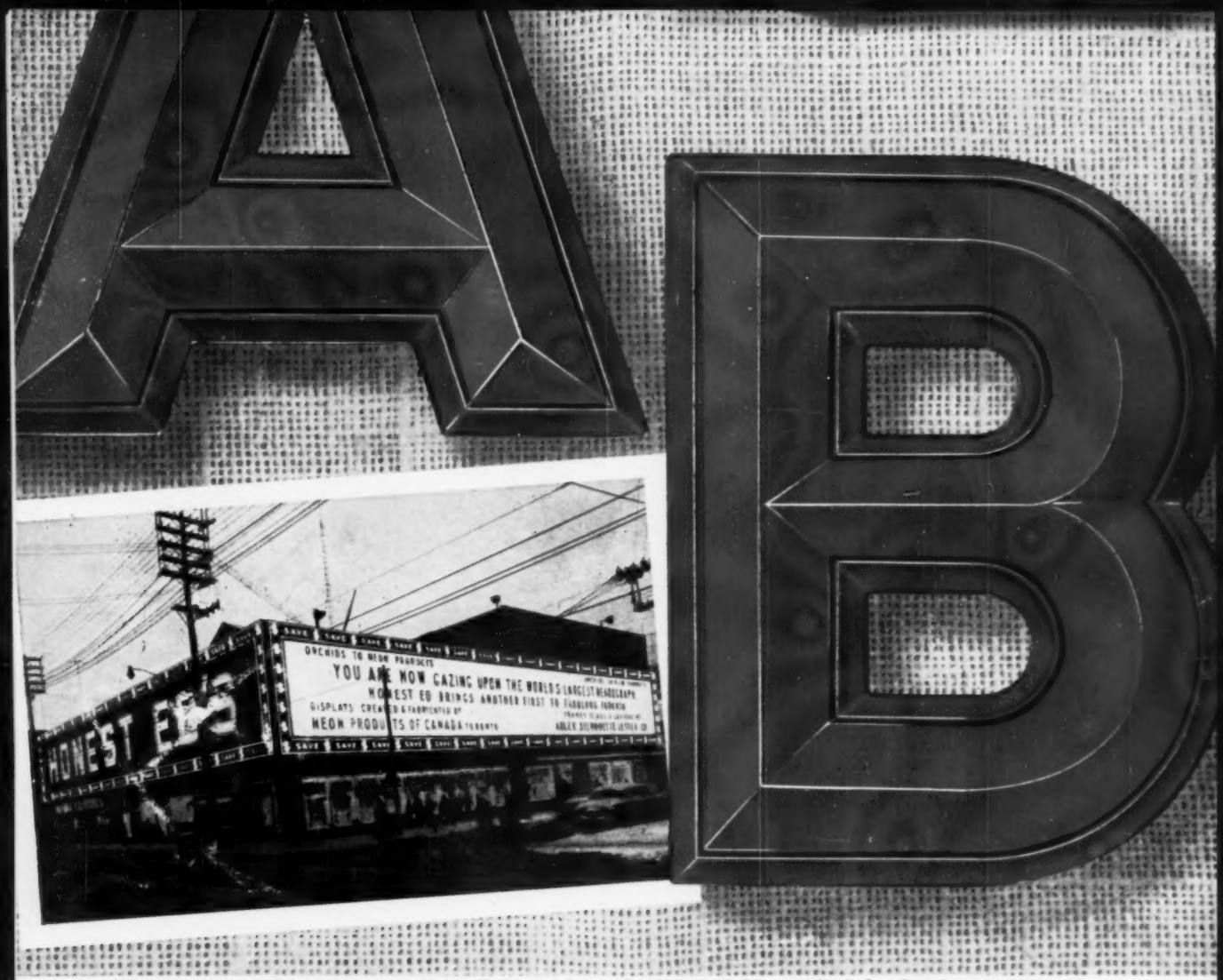


Letters molded of Tenite Butyrate by Adler Silhouette Letter Co., 11843 W. Olympic Blvd., Los Angeles 64, California.

The plastic that spells long life for changeable letters...**BUTYRATE**

Up in Toronto, you can find the world's largest changeable-letter sign, or as it's known north of the border—"readograph." The red, green, and black letters of this sign, 10,000 pounds of them, are all molded of a special weather-resistant formulation of Tenite Butyrate plastic.

As changeable displays have become increasingly popular among all types of retailers in recent years, Butyrate has become the most popular plastic changeable-letter material—*and for good reason.* Butyrate is a material whose toughness cannot be matched by any other weather-durable sign plastic. And it remains tough even in the cold weather to which this Toronto sign is sometimes exposed.

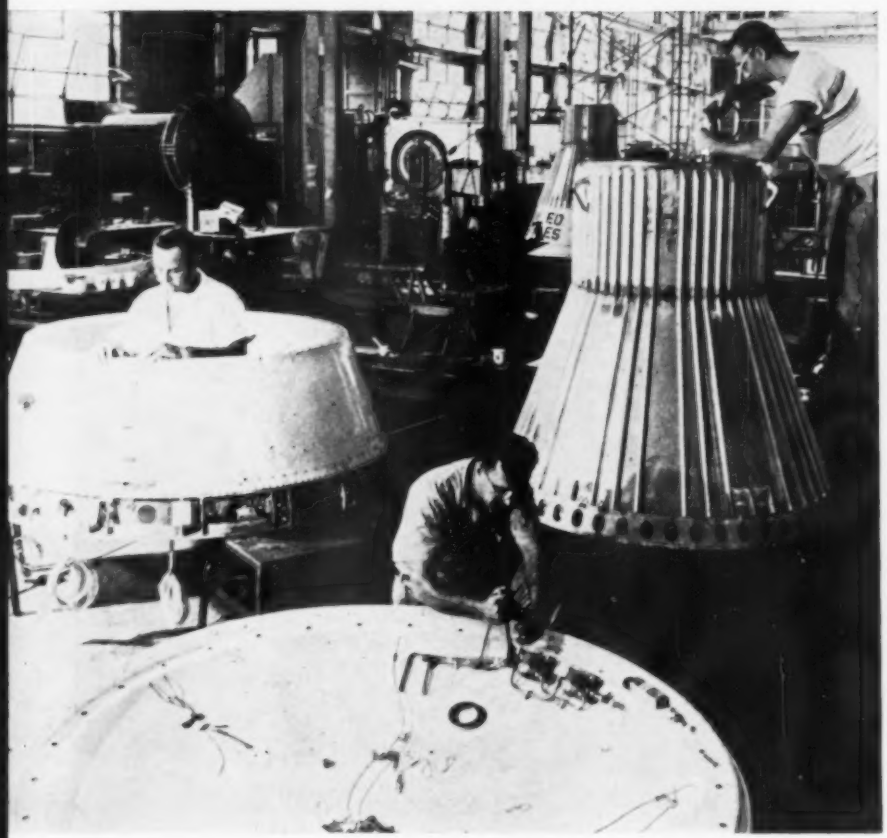
Toughness naturally is of primary concern to changeable-display customers because letters that are handled as often as once each day are sure to receive some rough treatment. Butyrate, "the tough sign plastic," has the impact resistance necessary to keep replacements at a minimum.

Molded letters are but one of many applications for Tenite Butyrate in the sign industry. Extruded sheet of this Eastman plastic is easily vacuum formed into imaginative sign faces and display elements characterized by outstanding visibility and long service life.

If you are not already familiar with the excellent outdoor performance characteristics of Tenite Butyrate—and the chance it offers you to improve the service life of outdoor products—write for further information to EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE®
BUTYRATE
an Eastman plastic

Product-Design
BRIEFS
from Durez



MORE ABOUT UNCLE'S MONKEY

Uncle Sam's first astronaut was a rhesus monkey, also named Sam, who took a 55-mile-high ride in a vehicle called Little Joe. It is Little Joe we're concerned with.

Specifically, with the part of Little Joe made from heat-resistant Hetron® polyester resin.

The full-scale Little Joe capsule is 9½ feet tall, 20 inches across the top and 6 feet across the rounded base. The bottom portion of this capsule consists of a heat-absorbing shield of glass-reinforced Hetron. Its several layers add up to an inch of thickness.

Hetron was chosen after intensive research because it provides an unusually high degree of inherent heat resistance, heat stability and fire resistance. All of these properties are important in coping with heat generated by atmospheric friction at escape velocity. Ease of fabrication was pretty important, too.

The large photo shows the two Hetron portions of the capsule: the bottom, in foreground; the heat-shield, at left.

Not only Uncle Sam's sophisticated scientists, but also the more prosaic industrial designers are interested in Hetron. It offers great promise in many different applications.

For example, it makes possible small boats that are fire-retardant. Because it is highly resistant to many acids, it finds wide use in scrubbers, ductwork and similar places where corrosive fumes quickly destroy other materials. It's being used for skylights on piers. One company even enclosed an entire building with it.

Hetron can by no means be considered a cheap substitute for other materials. Designers have been impressed with it and have used it simply because it performs its function better than any other material they might have used. Sometimes it costs less than other materials. Sometimes it costs more. But, in either case, it does things better, longer or more safely than anything else. We've got a data file on it if you're interested. Ask for Hetron File A.

A THOUGHT FOR USERS OF DIE CASTINGS

When you put these seven parts together, you get a highly efficient low-cost pump for emptying drums of gasoline, lube oil or chemicals.

The manufacturer used to die cast these parts. Now he has them molded from a Durez phenolic. The switch to molding from die casting eliminated many finishing and assembly operations. Even the fine threads on one of the parts were flawlessly molded.

The switch to phenolic from aluminum added greater corrosion and chemical resistance. Being non-metallic, phenolics also prevent sparking and minimize the risk of handling volatile liquids.

For more facts about molding with versatile Durez materials, ask for Bulletin D400.

For more information on Durez products mentioned above, check here:

- ☐ Hetron polyester resins (File A)
- ☐ Phenolic molding compounds (illustrated Bulletin D400)

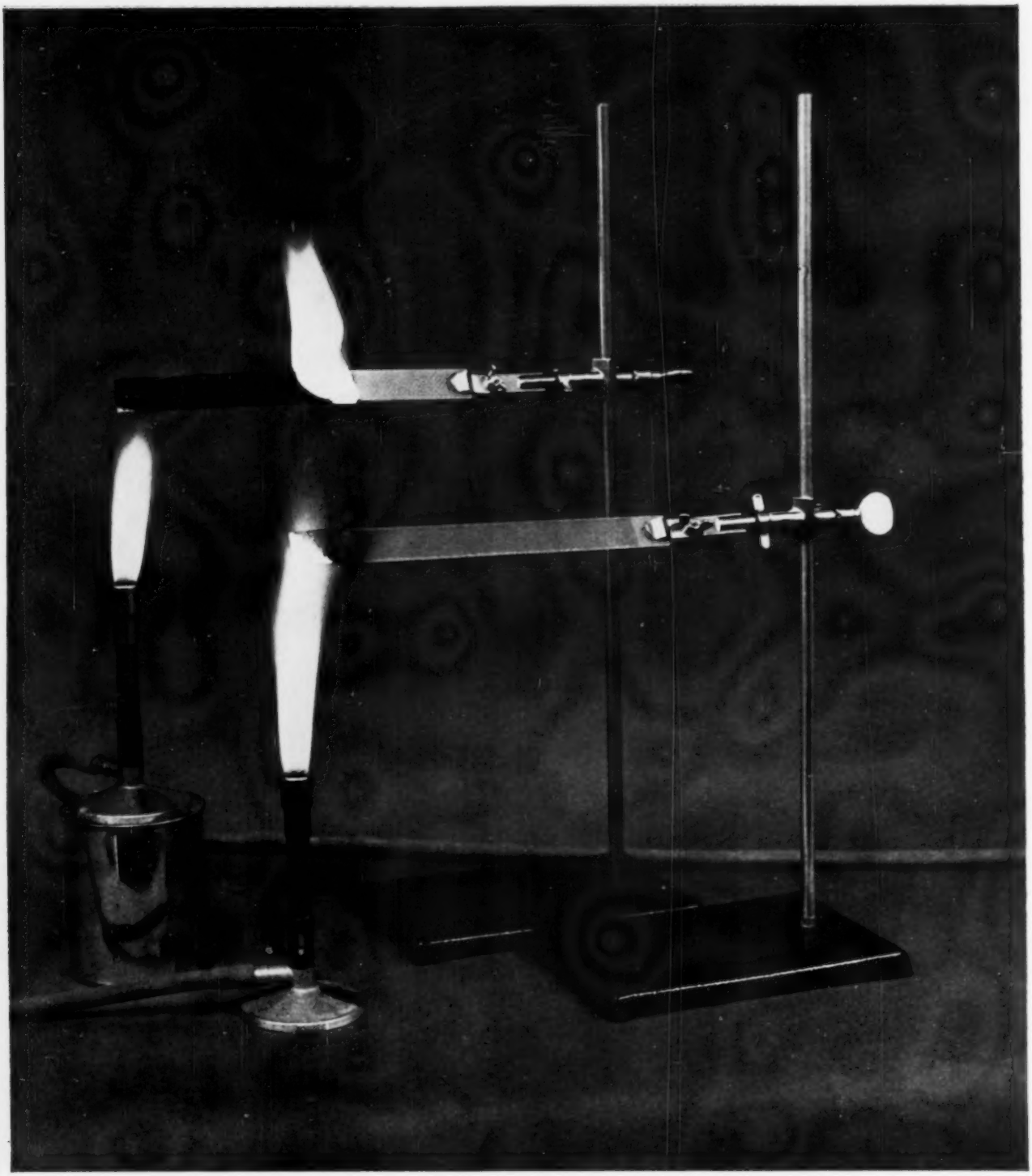
Check, clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

8610 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS



AROCLORS are COMPATIBLE with virtually all plastics resins • polyvinylidene chloride • cellulose acetate propionate • polyvinyl acetate • chlorinated rubber • ethyl cellulose • benzyl cellulose • polystyrene • nitrile rubber • phenolics • polyamides • epoxies • acrylics • urethanes • polyesters • polyethylene • nitrocellulose • polyisobutylene • styrene-butadiene • polyvinyl butyral • polyvinyl chloride • cellulose acetate butyrate

HOW TO "BUILD IN" HIGH RESISTANCE TO FIRE AND CHEMICALS WITH LOW-COST AROCLOR® PLASTICIZERS AND RESIN EXTENDERS

AROCLOR *chlorinated* polyphenyls—liquid or solid—offer remarkable *inertness*. They don't burn, evaporate, hydrolyze, or oxidize. They defy strong acids and alkalies. They blend readily with nearly all resins, solvents, plasticizers, and other plastics-compounding ingredients. You can choose from 13 standard AROCLORS—to impart outstanding flame retardance, chemical resistance, and other desired properties to your plastics compounds and protective coatings . . . *at low cost.*

NONBURNING EPOXIES

Aroclors are fully compatible with epoxy resins. Combined with a small amount of antimony oxide, they produce *nonburning* compositions. Aroclor 5460 yields epoxies with optimum compressive strength. Aroclor 1221 greatly improves flexibility.

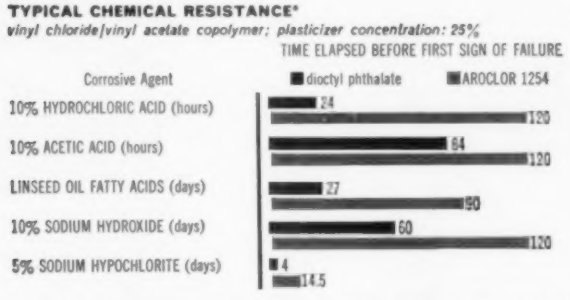
	AMINE-CURED EPOXIES		PHTHALIC ANHYDRIDE-CURED EPOXIES	
formulation	**control**	**modified**	**control**	**modified**
liquid epoxy resin	100	100	100	100
diethylenetriamine	13	13	...	...
phthalic anhydride	...	...	75	75
antimony oxide	...	5	...	5
DMP 30 (Rohm & Haas)	...	...	0.1	0.1
AROCLOR 1260	...	15	...	...
AROCLOR 5460	...	...	...	15
properties				
compressive strength, *psi*	43,000	38,150	23,400	40,700
flexural strength, *psi*	20,100	22,100	16,900	19,000
heat distortion, °C.	117.5	92	143	135
FLAMMABILITY— *inches per minute* (ASTM D635-56T)	0.82	NON-BURNING	0.6	NON-BURNING

EXTENDERS FOR PVC

Aroclors are especially effective as secondary plasticizers or extenders for polyvinyl chloride. Aroclor 1262, used 1:3 with dioctyl phthalate, sharply reduces migration to nitrocellulose lacquers. All Aroclor compounds can be used to improve the chemical resistance of vinyl chloride–vinyl acetate coating formulations.

TYPICAL CHEMICAL RESISTANCE*

vinyl chloride/vinyl acetate copolymer; plasticizer concentration: 25%



***Plotted from independent evaluation data by the Northwestern Paint and Varnish Production Club (The Official Digest, Nov. 1955). Conclusion: "The Aroclor 1254 had the best all-around chemical resistance."**

SELF-EXTINGUISHING POLYETHYLENE

Aroclor 5460 gives self-extinguishing, low-density polyethylene *with minimum effect on tensile strength or "memory."* Aroclor 5460 substantially improves heat stability, too, compared with other common flame retardants.

LOW-DENSITY POLYETHYLENE

formulation	**control**	**modified**
polyethylene	100	100
antimony oxide	....	10
AROCLOR 5460	....	20
properties		
melt index	1.96	6.2
% elongation	655	650
tensile strength, *psi*	2130	1710
yield strength, *psi*	1395	1300
FLAMMABILITY— *inches per minute*	7.1	NONBURNING

NEW BOOKLET gives the facts about "Aroclor Plasticizers" . . . compounding procedures, performance data, property tables, specific formulas. It tells how versatile AROCLORS could be your answer for better compounds at lower cost. Mail the coupon today

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Monsanto, maker of more plasticizers than any other company, provides these benefits to customers:

precisely right plasticizer systems

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able technical help in depth

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Organic Chemicals Division
Department 2714-A, St. Louis 66, Missouri

Please send me:

( ) PL-306, "AROCLOR PLASTICIZERS"

( ) CS-14, "AROCLOR PLASTICIZERS IN EPOXY RESINS"

I'm interested in Aroclors for.....resins.

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TITLE.....COMPANY.....

STREET.....

CITY.....ZONE.....STATE.....

Flying scale model of a P-40 fighter plane was molded by L. M. Cox Mfg. Co., Inc., Santa Ana, California.

TMD-2121, flame resistant modification of TMD-2100, was specified for the motor housing of the Shetland Floor Washing Vacuum Cleaner. Molded by Produx Co., Inc., Shrewsbury, Mass. for The Shetland Home Care Institute, Shetland Industrial Park, Salem, Mass.

Hot-and-cold picnic jug thermoformed by Columbian Enameling and Stamping Co., Terre Haute, Indiana, from sheet extruded by Kal Plastics Inc., Beaverton, Michigan.

DOLLAR FOR DOLLAR, THIS NEW STYRENE IS STRONGEST...

No other extra-high-impact styrene equals the new BAKELITE Brand compound TMD-2100.

It has better impact strength, elongation, and flex life. And these properties are maintained to an outstanding degree over the wide temperature range from —40 deg. C. to 60 deg. C. Compare that with any other extra-high-impact styrene.

On top of all this, TMD-2100 has the molding characteristics of lower impact styrenes. The extrusion grade produces excellent results in forming sheets for deep draw parts. If you need a flame-retardant material, there's a TMD-2100 type compound with that advantage, too.

Look at the examples shown here. For more than a year now, BAKELITE Brand extra-high-impact styrene TMD-2100 has been used to make durable, good-looking products like these. Try it yourself. For detailed information, write Dept. **EJ-105,** Union Carbide Plastics Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. *In Canada,* Union Carbide Canada Limited, Toronto 12.

Property Highlights of BAKELITE TMD-2100

All properties determined by ASTM methods on $\frac{1}{8}$-inch specimens cut from injection molded plaques.

	Typical Property Values		
	—40°C	23°C	60°C
Tensile strength, lb./sq. in.	4800	3200	2100
Elongation in Tension, %	22	44	58
Mod. Elast. in Tens., lb./sq. in.	302,000	245,000	200,000
Flexural Yield, lb./sq. in.	13,250	6,300	3,700
Mod. Elast. in Flex., lb./sq. in	360,000	290,000	195,000
Izod Impact Str. ft-lb./in. notch	1.4	6.3	9.0

UNION CARBIDE

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This Month in Brief

The lead article this month, "Ethylene Copolymers," describes specialized resins that differ from the homopolymer resins by providing better stress cracking resistance values and long-term bearing abilities. Their value in such applications as detergent bottles, wire and cable coatings, pipe, filaments, and other usages are discussed.

"Blow Molding - II. Role of the Extruder" offers the eagerly-awaited second part of the definitive series on blow molding. Part I - Fundamentals appeared in the July issue, and the forthcoming portions of the finished six-part series will be published in the near future. Watch for them in succeeding issues!

"The Hotbench Test Method for Determining Gelation and Fusion Characteristics of Plastisols" describes a simple, yet comprehensive, test method to characterize the change of state of plastisols on heating.

"The Effect of Molding Conditions on the Color of Reinforced Plastics Moldings" gives test results showing that the visual color of moldings is affected by changes in the filler content and type, as well as by changes or poor control of the techniques used to mix the formulations. The various factors affecting the color of moldings are compared.

"How Close Your Tolerance?" is the title (and subject) of this month's engineering forum on Compression & Transfer Molding, contributed by Paul Fina. Molders should pay special attention to the points brought out by Paul, particularly the points mentioned under General Observations.

"Adhesives - Part II" is the title of the enigneering forum, Consultant's Forum, by Dr. S.S. Stivala. Continuing the subject of adhesives begun in our August issue, he presents two more questions posed by the readers as well as his replies and discussions.

Exploring Fabrication Techniques presents a column on vinyl records, their fabrication, and some of the newest developments in formulations and methods of materials handling.

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What's new in processing

Prodex Corp. has developed a process for extruding rigid PVC pipe directly from dryblend—a substantial savings over compound. Ingredients are mixed in a Prodex-Henschel mixer for about 5 minutes. Highly viscous resins are used in combination with stabilizers, lubricants, and modifiers including both acrylic and ABS types to achieve an impact range of 15-25 lb./ft. Filler ratios of 2:1 can be used with sewer pipe. Dryblend is extruded on a vented, 24:1 L/D ratio Prodex extruder which eliminates porosity.

Less moisture absorption and therefore better dimensional control is reported with the new Foster Grant Fosta Nylon 62A-SK. A maximum spherulite size of 2.1 microns, as opposed to the normal nylon 6 size of 17-26, is said to account for it since amorphous areas absorb water faster than crystals.

Plastic-faced plaster tooling in less than 2 hours is announced by Rezolin, Inc. The firm's 832A Partingkote is applied to the reverse plaster pattern or mold, adding 826 wax if high gloss is desired. For hi-temp service, Rezolin 111 Compound is applied, followed by a sprinkling of aluminum fibers (hemp for low-temp). Suitable back-up casting plaster is applied—standard or Hydroperm for high-temperature service.

Plastics processors engaged in government contract work can take advantage of a new R & D lease plan through Nationwide Leasing Co., Chicago. Terms of 3-5 years are offered, with a cancellation clause.

Standard Oil Co. (SOHIO) reports a new and simple process for making acrylonitrile based on a single-step, direct conversion of propylene, ammonia, and air. Prospects call for lower cost material.

Abstracts

"Lacquer-Type Finishes for Plastics by the Fluidized Bed Technique" by E. Gemmer, Kunststoff-Rundschau, April, 1960, describes the method of using cellulose acetobutyrate and PVC to obtain decorative, varnished surfaces. The author tells how to avoid defects (hairline cracks), and describes coloring methods.

"Mass Production of Polyester Moldings" by E. W. Laue, Plastverarbeiter, March, 1960, describes two pre-pregs containing acetone as the solvent, which are non-adhering when dry and have a shelf life of 6 months. Equipment and molding conditions are given.

"Important Factors in Injection Molding" by V. Zilvar and L. Kupf, Plaste u Kautschuk, March, 1960, reports the redesigning of the CSB 1245 machine's heating cylinder by a Czech firm which is said to improve preplasticization and raise melt capacity in the injection molding of polyamides.

"Causes of Defects in High Vacuum Metallizing" by W. Wachendorff, Plastverarbeiter, Feb., 1960, reports inefficient evaporation, immediately apparent defects, and aging defects, offering practical suggestions for their prevention.

"Overcoming Sinkage and Voids in Thick-Section Moldings" by K. R. Lawrence and P. B. Wright, British Plastics, Feb., 1960, tells how to compensate for contractions of the polymer as it solidifies in the mold.

"Importance of Forming Temperature—Vacuum Forming in the Plastic Range" by W. Neitzert, Plastverarbeiter, March, 1960, describes tests on rigid PVC deep drawn in the plastic and elastic ranges. The former show lower impact and strength, poorer distribution of wall thickness. The latter have higher heat resistance, and equally clear-cut edges were obtained.

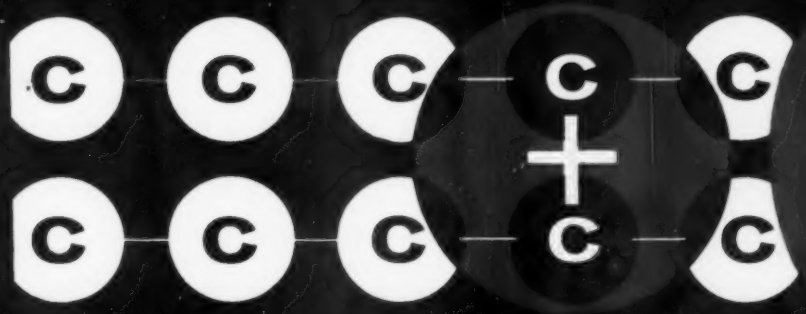
Patents

2,923,591 to Pittsburgh Plate Glass Co.—a method of dyeing polyvinyl butyral sheet by stretching 6-8% and dyeing it in a mixture of dye, dioxane, water, and morpholine.

2,925,622 to American Optical Co.—a method of hardening the surface of polyvinyl alcohol sheet by treatment with boric acid crystals and liquid water glass.

2,928,130 to Western Electric Co.—a method of extruding cellular polyethylene at alternate increasing and decreasing pressures. Gas is introduced at the sharp-decrease zone.

2,928,134 to Siemens Edison Swan, Ltd. (England).—a method of making lengths of polytetrafluoroethylene by cold-compressing the material in loose form, chamfering the ends, and again cold-compressing these units end-to-end in a trough by applying uniform fluid pressure through an intervening flexible layer.



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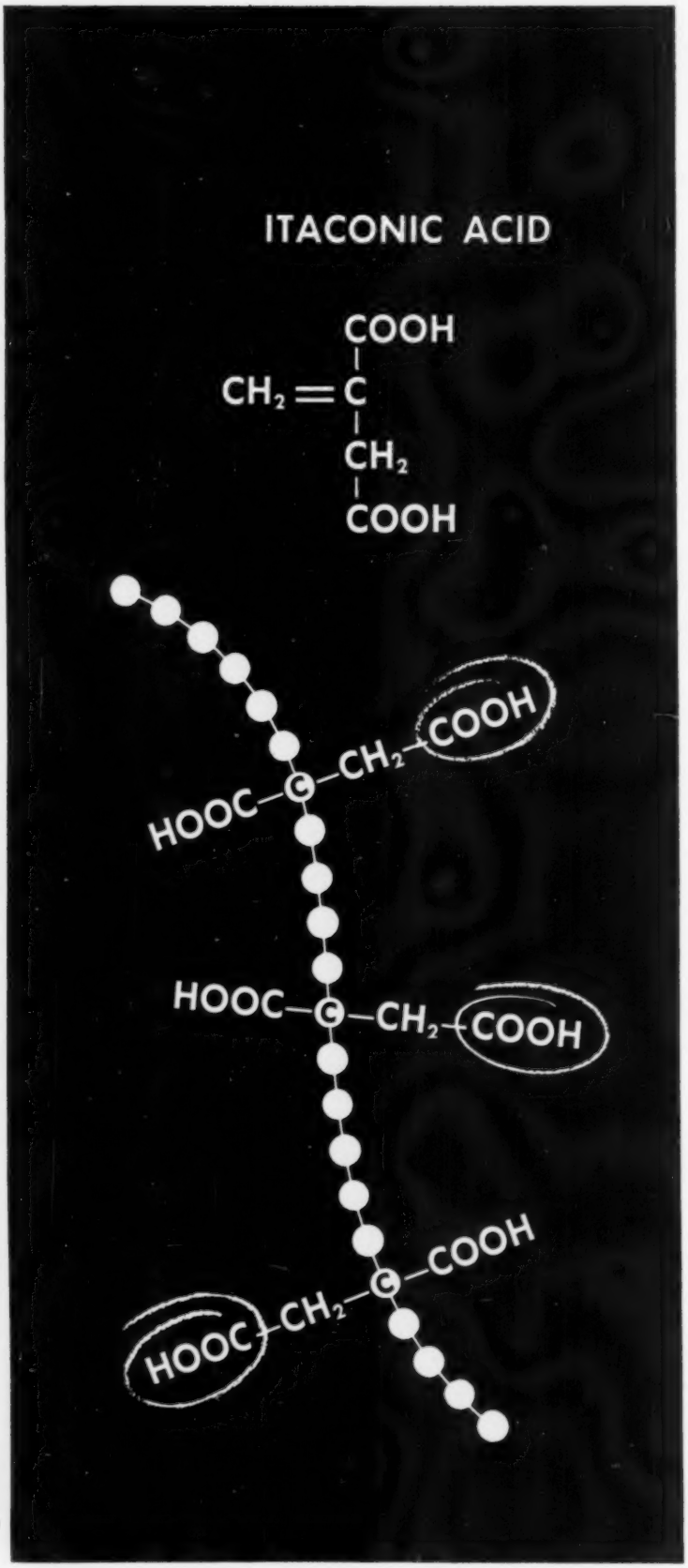

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Editorial: Business magazines — the hows and wherefores

All of you, as readers of PLASTICS TECHNOLOGY, are readers of at least one business magazine. As plastics processors, engineers, designers, and salesmen, you undoubtedly receive one or more other magazines in or related to the plastics field. At times, you may wonder why this seeming duplication of effort, or just what is their real purpose?

The answer is really quite simple. They all feel that they are serving an industry or a segment of that industry by supplying useful, pertinent information which enables the reader to do a better job. How do we do this at PLASTICS TECHNOLOGY? Let's see . . . . . .

Supplying this information is the sole duty of the editorial department, but it's a very complex one. Division of labor had its beginnings with the discovery of fire — man hunted the food, woman cooked it. In our era of specialization, however, no one person could write an up-to-date business magazine. The editorial staff's function is to assemble all available information and edit it for accuracy, readability, and reader interest. We can't bat a thousand, but this is our aim at all times.

Information comes from many and varied sources — the material supplier, the equipment manufacturer, the processor, and the end user — by direct, and by indirect methods — solicited and unsolicited. There's never a lack of information but, to determine its accuracy and timeliness, we consult our Editorial Advisory Board and other experts in the many fields within plastics.

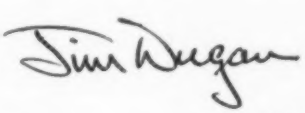
A little earlier I mentioned reader interest. This is the crux of our problem, and the area in which we are constantly striving to do a better job. If we do not know who our readers are and what are their interests, we have no right to exist — and won't, for long!

To determine these is the function of our circulation department, which "breaks-down" our 15,000 readers by job function and specialty. We know, for example, whether you are an extrusion engineer, an injection foreman, a slush molder of vinyls, or the production manager of a reinforced plastics molding plant.

With this information available, we can then contact a representative number or all of our injection molder readers and determine their current interests. Based on their replies, plus the percentage of injection molders among our readers we determine the type and number of injection molding articles to be run during a given year.

Too, we can go "across-the-board" as we did in a recent survey entitled "Do You Play the Ponies." We did not care whether you did or didn't, but did care about such things as: Did your company begin manufacture of new items last year, and how many? About 87% did, and the number of new items averaged 8. To the question "Did your company branch out into any new type of processing that year," 53% answered yes. Of this percentage, 14% went into blow molding, 34% into extrusion, 25% into compression molding, and 26% into injection.

Questions like these can and do indicate a distinct shift in reader interest — consequently, a shift has to be made in the number and types of editorial features. While this is by no means our only method of determining your needs and interests, we do most earnestly seek your cooperation in editorial surveys. In the long run, they will prove profitable for us all. Look for others in succeeding months!



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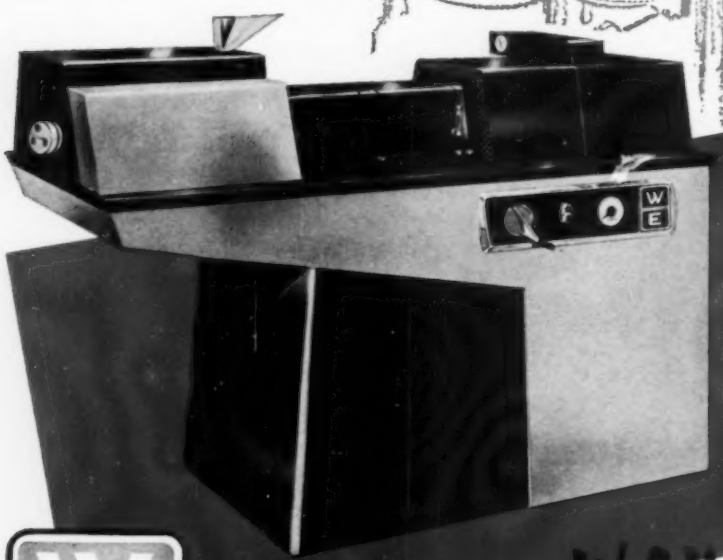

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PLASTICS
THE MAGAZINE OF APPLIED ENGINEERING
TECHNOLOGY

Specialized resins

offering stress cracking resistance

and long-term load bearing ability

Ethylene copolymers

J. E. PRITCHARD*
R. J. MARTINOVICH**
P. J. BOEKE***

Stress cracking has always been one of the major problems associated with the use of polyethylenes in certain critical applications. This was also true of the first commercial types of "linear polyethylene" which were suitable for many applications, but did not possess the resistance to stress cracking needed in detergent bottles or wire and cable applications. For this reason, Phillips started a research program to develop a tailor-made resin which would possess the stress cracking resistance required without sacrificing other desirable characteristics of linear polyethylenes.

This work resulted in the development of the ethylene copolymers. They are made by the copolymerization of ethylene with 1-butene, which yields resins containing short chain branches. The copolymer resins offer excellent environmental and thermal stress-cracking resistance plus long term load-bearing ability. In the following discussion the physical properties of the various types of copolymers now available will be presented. Particular emphasis will be placed on the low melt index, extrusion grade resin relative to its successful utilization in detergent bottles, wire and cable, fiber, and pipe applications.

Table 1. Typical Density Dependent Properties for Series 5,000 and 6,000

Property	ASTM Test	Co-polymer Series 5,000	Homo-polymer Series 6,000
Density	D1505-57T	0.950	0.960
Tensile strength, 20 in./min., psi.	D412-51T	3,800	4,400
Stress at yield, 20 in./min., psi.	D412-51T	3,800	4,400
Modulus of elasticity, psi.	D638-56T	110,000	150,000
Stiffness in flexure, psi.	D747-50	115,000	150,000
Hardness (Shore D)	—	67	68
Vicat softening temperature, ° F.	D1525-58T	255	260
Heat distortion temperature, ° F.	D648-56T	160	170

* Mgr. Appl. Research Sect., Plastics, Resch. Div., Phillips Petroleum Co., Bartlesville, Okla.
** Lab. Supervisor, Eval. & Compds., Phillips Chemical Co., Bartlesville, Okla.
*** Mgr., Sales Service Lab., Phillips Chemical Co., Bartlesville, Okla.

Physical Properties

The copolymer resins are characterized by a nominal density of 0.95. Therefore, properties related to density should be somewhat different from the 0.96 density homopolymer. Table 1 shows typical density-dependent properties of the copolymer resins (Series 5000) compared with the 0.96 density resins (Series 6000). In general, these data show that tensile and flexural properties are more responsive to changes in density than the thermal properties. There are certain properties, however, such as ESC, brittleness temperature, elongation, and impact strength which, although affected by density, are also dependent on molecular weight. This is illustrated in Figure 1, where these properties are plotted vs. melt index for the copolymer and homopolymer resins.

The copolymer series has higher elongation and, in the higher melt index types, better brittleness temperature. Comparison of Izod impact values for the two resin series shows consistently lower values for the co-

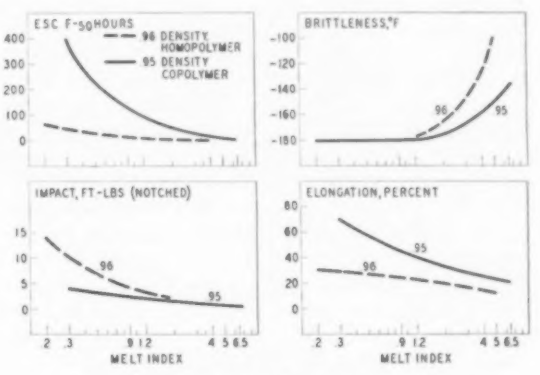


Fig. 1. Effect of Melt Index on Resin Properties.

Table 2. Stress Cracking Resistance (F_{50} Values) at 50° C. (Bell Test)

Environment	0.950 Copolymer	0.960 Homopolymer
Igepal Co-630	300-400	60
Silicone DC-200	>1,000	43
Ethyl alcohol, 100%	>1,000	20
Acetic acid, glacial	>1,000	9
Sodium hydroxide, 5%	670	34
Ethylene glycol	>1,000	40
Methyl ethyl ketone	>1,000	34
Diisooctyl sebacate	>1,000	36
Ivory soap solution, 5%	350	20

Table 3. Long Term Testing of Detergent Bottles

Bottle	Bottle Size (Ounce)	Wall Thickness (Mil)	125° F., >120 Days
A	4	20	No failures
B	12	32	No failures
C	12	32	No failures
D	22	35	No failures
F	32	30	No failures

Table 4. Effect of Temperature and % Fill on Shelf Life

	140° F.	150° F.
10% Fill	41 Days	5 Days
100% Fill	72 Days	22 Days

the low melt index extrusion-grade copolymer resin. Further indication of this is shown by Table 2, which lists the F_{50} values of the 0.3 melt index copolymer in a number of common severe stress cracking mediums. Susceptibility to stress cracking is usually accepted as being dependent on molecular weight, density and, to a minor extent, on molecular weight distribution. The 0.3 melt index copolymer resin has an optimum balance of these three parameters. The remaining sections of this paper will deal with the use of 0.3 melt index copolymer resin in four large volume applications.

Detergent Bottles

Although the Bell test gives some indication of resins' relative resistance to environmental stress cracking, it cannot always be correlated with a specific application. Therefore, any program aimed at developing a resin specifically for detergent bottles must include actual bottle testing. In general, bottle tests can be classified either as long term or accelerated. Since the actual test conditions vary considerably from one laboratory to another, we will limit our discussion only to those tests which were developed over a period of time in our laboratory.

A very important factor to be considered in bottle testing is bottle design. Such decorative features as

Table 5. Ten-Day Accelerated Tests of Detergent Bottles — 10% Fill

Bottle	Bottle Size (Ounce)	Wall Thickness (Mil)	140° F.	150° F.
A	4	20	No failures	No failures
B	12	32	No failures	No failures
C	12	32	No failures	8 Days
D	22	35	No failures	8 Days
E	22	36	No failures	No failures
F	32	30	No failures	5 Days
G	32	30	No failures	No failures

Table 6. Six-Foot Bottle Drop Tests at Various Temperatures

Bottle	Size	Wall Thickness	80° F.		40° F.		0° F.	
			Bottom	Neck	Bottom	Neck	Bottom	Neck
A	4	20	Passed	Passed	Passed	Passed	Passed	Passed
C	12	32	Passed	Passed	Passed	Passed	Passed	Passed
D	32	26	Passed	Passed	Passed	Passed	Passed	Passed
F	32	30	Passed	Passed	Passed	Passed	Passed	Passed

polymers. Possibly this reflects a higher notch sensitivity for the copolymer resins under the Izod loading of 11 ft./sec. Such lower Izod values would normally lead to the conclusion that the copolymer resins do not possess good toughness. Actually, this is not the case. Other tests commonly used to assess toughness are the falling ball and the tensile impact test. These tests, shown in Figure 2, indicate a much smaller difference between the two resin series with respect to toughness.

By far the biggest difference between the copolymer resins and the 0.96 density resins is in resistance to stress cracking. Figure 1 shows a plot of environmental stress cracking (F_{50}, Bell test) versus melt index. From this plot, it is evident that the copolymer series of resins consistently show greater resistance to environmental stress cracking than do the homopolymer resins. Furthermore, this property is exhibited to a high degree by stepped-designs, ribs, etc., cause severe stress concentrations and can have a definite effect on bottle performance. Although the bottle tests presented here represent a wide range of bottle designs, no attempt will be made to present a correlation between bottle geometry and bottle performance. The test data reported in this paper is based on bottles made with commercial bottle blowing equipment.

Another important factor is the type detergent used. Some commercially available detergents are more effective stress cracking environments than others. We found Joy to be one of the most effective surfactants in causing stress cracking in bottles and used it in all the test data reported in this paper. It has been our practice though, when testing bottles to be used for a specific commercial product, to test this product in addition to Joy.

Our first long-term aging tests consisted of filling test bottles to 100% capacity with a detergent and capping them at ambient temperature. The bottles were aged in an oven maintained at 125° F., and examined daily for stress failures. As you will note from Table 3, no failures were recorded after 120 days. It was obvious, therefore, that more severe test conditions would have to be imposed on the containers in order to screen detergent bottles in a shorter time. One means of

Table 7. Thermal Stress Cracking Test at 160° F. Failure Time in Hours Versus % Strain

	Hours To Failure	
% Strain	0.3 M.I. Copolymer Resin*	0.2 M.I. 0.96 Density Homopolymer*
40	>1,000	<1
30	>1,000	<1
20	>1,000	<1
10	>1,000	7
5	>1,000	>1,000

* Stabilized with 0.1% Santonox.

Table 8. Thermal Stress Cracking Test on 0.3 M.I. Copolymer at Various Temperature 1/8 In. Molded Specimens Strained at 37% in Bell Laboratory Channel

	Hours to Failure	
Temperature	Natural Copolymer*	Black Compound*
180° F.	1,000	1,000
212° F.	1,000	1,000
250° F.	1,000	1,000

* Stabilized with 0.1% Santonox.

Table 9. Twisted Wire Test Stress Crack Resistance of 0.3 M.I. Copolymer Resin

	Hours to Failure	
	Natural*	Black Compounded*
212° F. Air Oven Test Coated #14 copper wire	>2,500	>2,500
250° F. Air Oven Test Coated #14 copper wire	>2,500	>2,500
195° F. 50% Igepal Test Coated #22 copper wire	>1,000	>1,000
180° F. Distilled Water Test Coated #14 copper wire Specimens aged for 14 days at 100° C. prior to test.	>1,000	>1,000

* Natural resin stabilized with 0.1% Santonox.

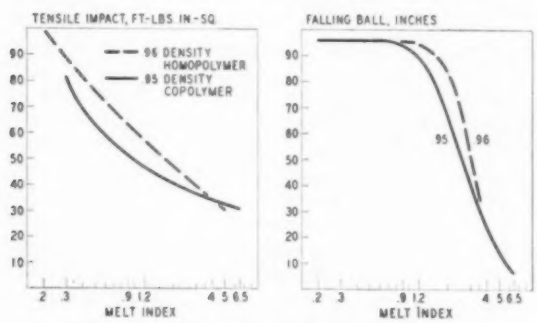


Fig. 2. Effect of Melt Index on Impact Properties.

James E. Pritchard is a native of Iowa. He received his BA and MS Degrees in Chemistry from the State University of Iowa in 1942 and 1943, respectively, and his PhD from Purdue University in 1948. Since 1943 he has been employed in the Research Division of Phillips Petroleum Company and currently is Manager of the Applications Research Section, Plastics Branch.

Robert J. Martinovich was born in Chicago and attended Marquette University, receiving an MS Degree in Chemistry in 1954. He was an instructor in Chemistry at Marquette from 1954 to 1955. In 1955 he joined Phillips Petroleum Company as a chemist in their Plastics Application and Research Group. He transferred to Phillips Chemical Company in 1956, becoming Group Leader in charge of evaluation and compounding in 1957. In March of 1960 he assumed his present position as Laboratory Supervisor of evaluation and compounding.

Paul J. Boeke is a native of Ohio and received his education at the University of Dayton and Princeton University, from which he received an MS in engineering in 1949. He was an engineer at the Wright Field Air Service Command from 1942-1944; in service with the Navy from 1944-1946; research chemist for the Wright Field Air Material Command from 1946-1947; and research chemist in the engineering division of Chrysler Corp. from 1949-1952. He joined Phillips Petroleum in 1952 as Group Leader in the Research Division, and was appointed to his present position with Phillips Chemical Co. in 1956. Mr. Boeke is a member of ACS, SPE, ASTM, and Sigma Xi. He resides currently in Bartlesville with his wife and two children.

Table 10. Electrical Characteristics and Other Properties for Wire and Cable Uses

	Natural	Black Compound
Dielectric constant		
1 Kilocycle	2.35	2.64
1 Megacycle	2.35	2.62
Dissipation factor		
1 Kilocycle	0.0002	0.002
1 Megacycle	0.0003	0.004
Dielectric strength		
1/8 in. thickness—V/mil	500	475
Volume resistivity	$>6 \times 10^{15}$	—
Abrasion resistance		
Armstrong CM^3/100 cycles	0.24	0.24
Hardness, Shore D	67	67
Tensile strength, stripped wire		
Unaged — 20 in./min.	—	3,160
2 in./min.	—	2,990
Aged — 20 in./min.	—	3,340
2 in./min.	—	3,010
Elongation, stripped wire		
Unaged — 20 in./min.	—	130
2 in./min.	—	800
Aged — 20 in./min.	—	70
2 in./min.	—	650

Table 11. Typical Filament Properties

Denier per filament, grams/9,000 M	20-1,000
Specific gravity	0.950
Tenacity, grams/denier	6-8
Tensile strength, psi.	60,000-100,000
Elongation, %, 12 in./min. crosshead speed	5-30
Shrinkage, %, 5 min., 212° F.	9

accelerating bottle failures is to increase the test temperature. Another effective method was to reduce the volume of detergent in the bottle.

The effect which these variables have on short time bottle tests is indicated in Table 4. At 100% fill, an increase in temperature from 140° to 150° F. decreases detergent volume from 100% to 10% at a given temperature. Based on these results, a fill of 10% and temperatures of 140° and 150° F. were chosen for our accelerated tests. Results obtained using these conditions are summarized in Table V. These data indicate the excellent stress cracking resistance of copolymer bottles.

Although the test methods described deal primarily with increasing stress cracking resistance, another important consideration for any application involving bottles is impact strength. To determine the over-all toughness of these copolymer containers, bottles were filled with water brought to the test temperature and dropped from a height of six feet on the bottom and neck. These bottle drop tests, illustrated in Table 6, show the excellent toughness of these bottles even at low temperatures.

Wire and Cable Coating

Use of the early "linear polyethylene" resins by the Wire and Cable Industry did not materialize as expected. Although they were extremely tough, abrasion and temperature resistant, and had excellent electrical properties, their low resistance to thermal stress cracking made them unsuitable for wire and cable service.

Preliminary screening tests with the low melt index copolymer resins revealed that they do not have the same susceptibility to thermal stress cracking. This is shown in Table 7, which compares failure times for the copolymer and 0.96 density resins under constant strain of 5-40% at 160° F. In this test, 1/8-inch compression molded strips were bent around mandrels of varying radii to impose predetermined strain on the outer surface and the time to cracking was noted.

Table 8 reports another test in which 1/8-inch compression-molded specimens were bent in a channel that imposed a constant strain of 37%. Specimens were then subjected to temperatures ranging from 180° to 250° F. Again, the low melt index copolymer resin showed no failures while the homopolymer resin failed at all temperatures in less than 24 hours.

A third test commonly used by the Wire and Cable Industry is the twisted wire test. Here, high strains are imposed by twisting the coated wire around its own diameter. In other versions of this test, the twisted wire is either exposed to elevated temperatures in a forced draft oven or to elevated temperatures in a stress cracking environment. Table 9 illustrates the excellent thermal stress crack resistance of both natural and black copolymer resin in the twisted wire test.

In other desirable properties such as abrasion and temperature resistance, chemical inertness, and general electrical properties the copolymer resin is similar to the 0.96 density resin. Table 10 shows some of the pertinent electrical properties of the natural and black copolymer resin.

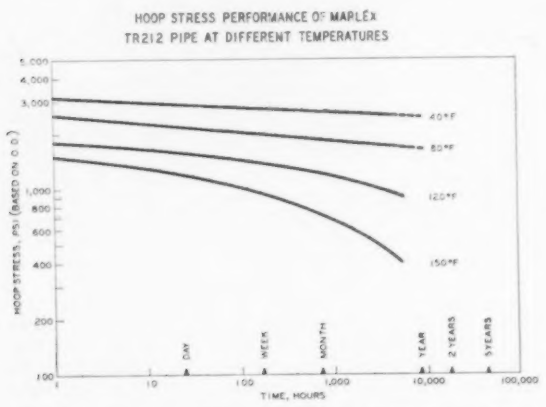


Fig. 3. Hoop Stress Performance of Marlex TR212 Pipe at Different Temperatures.

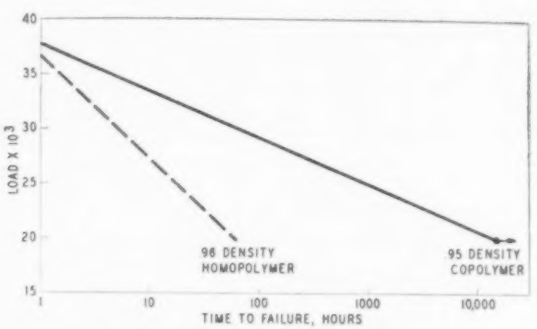


Fig. 4. Stress Life Curve for Polyolefin Monofilaments.

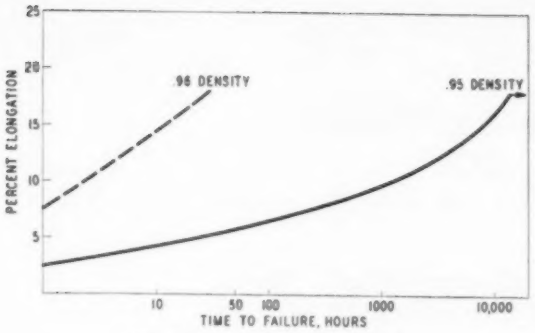


Fig. 5. Creep Rate at 20,000 psi.

Pipe

The improved resistance to stress cracking and superior load bearing properties of copolymers have stimulated interest in their use as pipe materials. In order to obtain the highest level of performance consistent with good processibility, a 0.95 density polymer of 0.2-0.3 melt index is recommended. This yields a glossy pipe at good rates, using any of the standard polyethylene extrusion techniques. Although the copolymer exhibits a relatively high modulus and a hard surface, the pipe is coilable in sizes up to 1½ inches. Standard insert and clamp type fittings can be used without difficulty. Larger pipe sizes for drain lines and low pressure service are available in standard lengths which can be joined by melt fusion methods.

Stress-life tests have been underway for six months and will be continued until complete performance characteristics are determined. As indicated in Figure 3, test temperatures of 40°, 80°, 120°, and 150° F. are being used. Temperatures of 120° F. and higher are included in order to accelerate the stress failures and to assist in predicting long term life at lower temperatures. However, it is anticipated that copolymer pipe will be used for cold water, brine, natural gas, or similar service where temperatures will not exceed about 90-100° F. In a typical 1,000-hour test with a water environment at 80° F., the hoop stress at rupture is 1,800 psi. This exceeds the proposed commercial standards for high density polyethylene pipe both in the temperature of testing and in performance under stress.

Filaments

High density polyethylene homopolymers are well suited for the production of filaments. High rates of drawing are easily accomplished in hot air, hot water, or steam. These filaments have excellent physical properties including high tenacity and abrasion resistance. However, if the filament has to bear a continuous load for extended periods of time, it must possess long term stress retention. This is especially desirable in such applications as rope, cordage, or webbing where the filaments are likely to bear continuously high loads. The lower density copolymers were found to possess the same excellent filament characteristics of homopolymer resins (Table 11). In addition, these filaments exhibited a substantial improvement in load bearing properties. This is illustrated in Figure 4, in which the comparative stress life curves of copolymer and homopolymer filaments are presented. This is also evident from Figure 5, which shows typical creep curves for the two resins in question.

Other Applications

There are a number of applications in which higher melt index copolymer resins can be used to advantage, such as injection molding and film extrusion. These resins are especially desirable for metal insert and industrial moldings where resistance to stress cracking is of prime importance. They also perform satisfactorily in slot extruded film, where softness and greater clarity are required. In summary, the 0.95 density copolymer resin, with its exceptional stress cracking resistance and excellent load bearing properties, should extend the uses of polyolefins in the Plastics Industry.

—The End

Circuit pattern transfer system

The use of a plastic-paper template to transfer circuitry patterns onto copper clad, glass-epoxy boards is now standard procedure at Librascope, Inc. According to the Glendale, Calif., company, the process was adopted to reduce alignment and damage problems and to insure dimensional stability of the negative.

Formed by bonding a sheet of thin, translucent paper to rigid plastic, the template eliminates problems caused by the sensitivity of the photographic film previously used. Further, the plastic backing has permitted the development of an automatic alignment feature. Pins in the corners of the plastic negative support correspond with holes in the board, and hold the board firmly during the photographic process.

Sandwiches of reinforced plastic coated with photosensitive copper are used for the boards.

Blow Molding—II

Role of the extruder

Importance of the extruder in the blow molding process

ALBERT A. KAUFMAN*
AND
ISLYN THOMAS**

In extrusion blow molding, the extruder represents an important part of the installation.

1. It must operate continuously or, in some cases, intermittently to produce a suitable parison.
2. It must deliver a parison which maintains uniformity of cross section along its length.
3. It must deliver the parison at a controllable stock temperature.
4. It must deliver a well plasticated parison free of surface blemishes.
5. It must have enough capacity to fulfill all the above requirements at a production rate permitting the fastest possible cycle.
6. It must guarantee good mixing action in order to permit the use of color blend.
7. The machine elements and instrumentation of the extruder must guarantee good repeatability and maintain regular output over long periods of time.

To have and to maintain an efficient blow molding operation, one must know and understand the basic principles of extrusion and the importance of producing the right parison for a given job.

Parison Uniformity

Uniformity of the parison in blow molding is of paramount importance. The extruder must deliver an extrudate within close mechanical tolerances and without variations. (See Fig. I). Irregular extruder output causes weight variations from one blown part to the next. Variations are costly—too heavy a part uses extra material not originally calculated; too light a part is mechanically unacceptable and becomes a reject. A variation in extruder output within the same parison might produce a part with correct weight, but it may be too thin at a critical point of the product. In general, this happens at a sharp bend in the blown part, such as at the shoulder or bottom of a bottle.

In weighing commercially available blown parts of similar make and design, weight variations as much as 30% have been observed. This means an unpredictable material cost variation plus a large variation in hourly production. Such "out-of-tolerance" heavier parts also require a longer cooling cycle. If cooled too short a time, they become rejects because of deformation, tearing, etc.

The above examples show that considerable thought should be given to the selection of the extruder in blow molding. The facts disprove a frequently heard statement: "as long as the extruder produces a parison, it is good enough for blow molding."

Adjustable Speed

In order to synchronize the extrusion speed of the parison with the best possible blow molding cycle, it is necessary to have a motor drive with a continuously adjustable speed. The speed variation can be obtained electrically or mechanically, and should have an adjustment range in the ratio of at least 4:1. The motor drive should be positively connected to the main drive shaft of the extruder with a flexible coupling, an electro-magnetic coupling, or a chain drive. These methods are generally preferable to a belt drive.

Head and Gate

An extruder head and gate serves to attach any desired dies and should be designed to avoid heat losses and to permit easy screen pack and die change. Modern extruders use streamlined hinged gates with built-in electric heaters (See Figs. I and IV). The heaters bring the head and gate up to operating temperatures and then act to offset heat losses. Heads and gates without heaters may cause slow start ups because the mass of these elements is not at the proper operating temperature.

Operation and Maintenance

Since man hours in maintenance and in lost production are very costly, an extrusion machine for blow molding must be designed for maximum convenience in operation and maintenance. Skilled labor is scarce; therefore, the installation must require a minimum of "skilled" attention.

Provisions have to be made to remove the extrusion screw easily and in a minimum of time. This is done in modern extruders with a semi-automatic screw push-out. Good design obviates the use of screws, bolts, or nuts to fasten machine guards. They complicate guard removal and are apt to be lost. Fast and easy guard removal encourages inspection of heating and cooling circuits and thermocouple locations.

* Albert A. Kaufman, Prodex Corporation, Fords, New Jersey
** Islyn Thomas, Newark Die Company, Newark, New Jersey

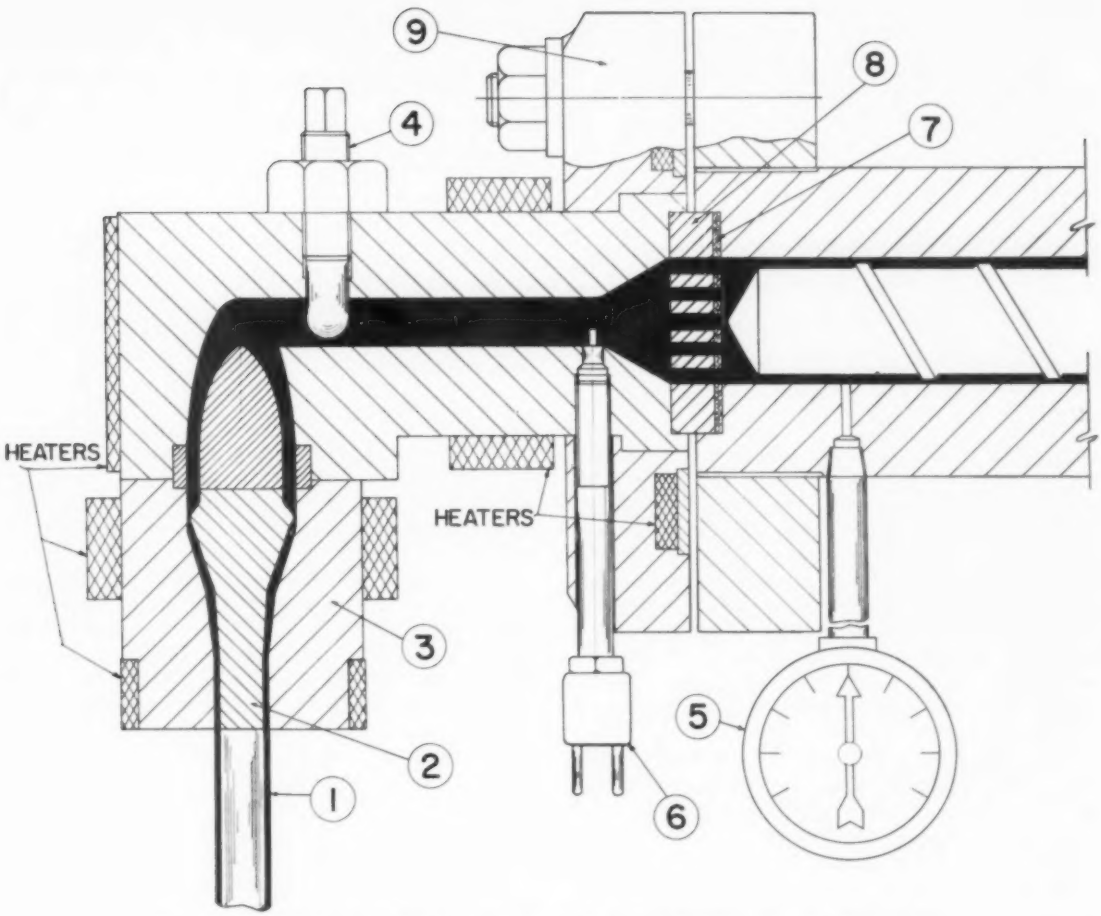


Fig. 1. Extruded Parison: 1.—Parison, 2.—Core, 3.—Die, 4.—Adjustable valve, 5.—Pressure gage, 6.—Stock thermocouple, 7.—Screen pack, 8.—Breakerplate, and 9.—Swing gate.

An important functional part of the machine—the thrust assembly—must be easily accessible to inspect oil flow, oil cleanliness, and general condition of the bearing assembly. Some machines are equipped with sight glasses which permit complete inspection at all times during operation. The removal of the thrust assembly should be possible without unmounting other machine parts or without affecting the alignment of other machine elements. This is accomplished in some machines by the use of a flexible coupling between gear transmission and thrust assembly (See Fig. VI). Others use a chain or cog belt transmission directly to a gear head motor. These also permit easy access to the thrust assembly.

Head and gate assembly should be designed to interchange different heads or dies easily and rapidly without skill. The above mentioned are the most important refinements which a modern extruder should have. They require a somewhat higher original capital outlay, but this is largely justified in terms of time and labor saved.

Length/Diameter Ratio

To produce a parison of good uniformity, the extruder should have a length to diameter ratio (L/D ratio) of at least 20:1.

L—Length of barrel from front end of feed opening to front end of barrel.

D—Inside diameter of barrel.

This means the active screw length on the cylinder past the feed section of an extruder should be twenty times longer than the screw diameter.

Extruders with lower L/D ratios have been used and are still being offered. The shorter machines, however, produce a parison of less uniformity. They also, in many cases, produce less pounds per hour than the longer machine. The longer machine permits a more gradual and uniform heat and energy input into the material because of the longer passage of the material through the machine. This, in turn, produces an extruded parison of more uniform viscosity. It also permits better control and uniformity of stock temperature—the temperature of the molten plastic. The advantage of a longer machine over a shorter one is readily brought out by the following illustration (See Fig. II):

The screw action in each case consists of a certain number of flights for dry solids conveying, in which the material is picked up from the feed opening and compressed into the extruder cylinder. After approxi-

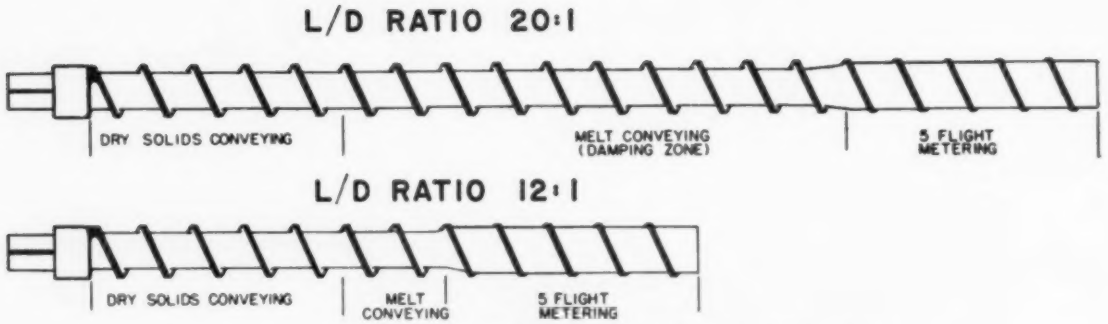


Fig. II. Comparison of Damping Zones for Screws with L/D ratios of 12:1 and 20:1.

mately five flights, the material begins to melt and enters the melt conveying section of the screw. This is, actually, the most important part of the machine, since the material should be brought to a uniform melt viscosity before it reaches the metering section. If we assume that a metering section of five flights is used, we have a melt conveying section of two flights in a 12:1 L/D ratio screw, five flights in a 15:1 L/D ratio screw, and ten flights in a 20:1 L/D ratio screw. Thus, an increase in L/D ratio will provide a large and direct increase in the melt conveying or damping zone.

The longer screws operate with a minimum of feed surging and problems, since the conveying action of the screw becomes very positive and uniform. The longer screw also permits the use of lower cylinder temperatures for the same melt temperature. A very narrow range of stock temperatures is, therefore, present in the extrudate. The narrow melt temperature distribution permits more precise and homogeneous extrusions. It also allows a less critical temperature setting. Heat sensitive polymers are extruded more readily on longer machines, since the cylinder temperature can be maintained at a lower level for a given stock temperature than with a shorter machine.

Heat degradation problems are initiated by the small percentage of material in the extremely high temperature portion of the stock temperature distribution. This portion is substantially reduced by the use of a longer machine. These considerations are true for machines operated adiabatically (heating supplied by screw energy), and those operated with heat input through the cylinder.

The machine with the greater L/D ratio also does better mixing when dry color blends are to be used. A longer machine thus provides every advantage in extrusion quality and is, therefore, the most economical machine to use. We feel that it is decidedly advantageous to use machines with an L/D ratio of at least 20:1, in preference to shorter machines. The small saving in machine purchase price for the shorter machine is not justifiable economically.

Screw and Cylinder

The extrusion screw and the extrusion cylinder are subject to constant abrasive action under considerable pressure. A fixed clearance between extrusion cylinder and screw flights is necessary and must be maintained. Therefore, it is necessary to use a cylinder lining material of excellent abrasion resistance such as Xaloy (See Fig. III). Furthermore, the screw flights should be hard-surfaced with stellite, colmonoy, or other tungsten-type hard surfacing materials. This combination is much preferred to nitrided cylinders and screws since its abrasion resistance is greater and the co-efficient of

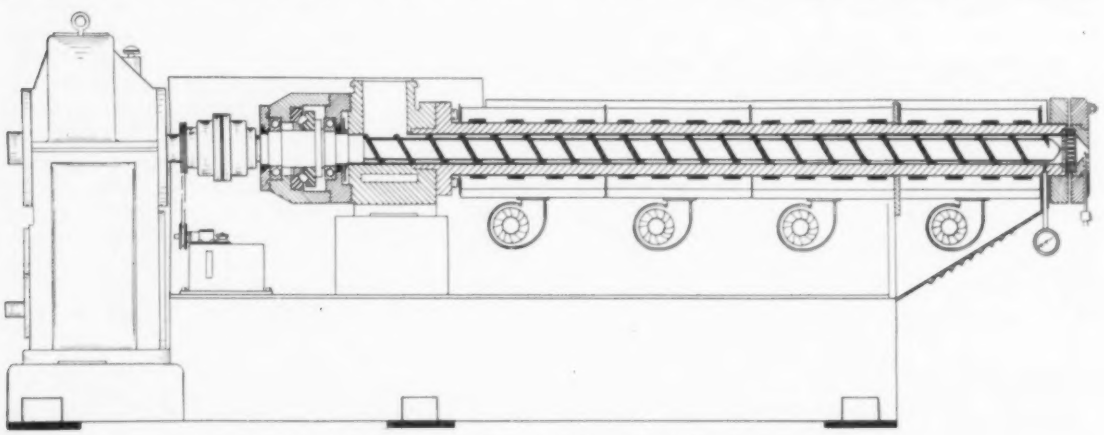


Fig. III. Sectional view of modern aircooled extruder.

friction is lower. Many years of field experience have proven this point. Hard surfacing of screw flights is also superior to flame hardening. At operating temperatures of modern polymers (500° F. and higher), flame hardened screw flights gradually lose their original hardness and their wear resistance decreases accordingly. The screws should be made of alloy steel with good torque and fatigue resistance. It is the torque capacity of the screw at its weakest section that determines the maximum horsepower input permissible at a given speed. It should also be noted that, in intermittent extrusion blow molding, the screw has to start up at each cycle with a full extruder. In such cases, the screw has to be made of a steel with high fatigue resistance.

Screw Design

The screw is really the heart of the extruder; therefore a short explanation of screw function and screw design is necessary. First, there is no such thing as a perfect universal screw which will provide optimum performance with all thermoplastics.

The geometry of an extrusion screw designed for maximum output rate is dependent upon the melt viscosity of the compound. This means that a given screw can provide optimum performance only with material of the viscosity for which the screw was designed. It is recommended, therefore, that various screws designed for different materials be purchased with the extruder. Well designed extruders are equipped to change screws easily in a matter of minutes. In practice, good compromises in screw design have been reached, offering high output rates for a number of thermoplastic materials with different melt viscosities.

Screws, designed according to the latest rheological data, are provided with three working zones:

Zone 1.—Granule or dry powder pickup an initial transport (feed),

Zone 2.—Compression and heating to a state of fusion, and

Zone 3.—Pumping of the hot melt at a controlled and steady rate toward the die (metering section).

The channel depth and the channel depth ratio of these three zones are different for different polymers. These factors will be very dependent on size, form, and surface of the granules (or powder) to be conveyed as dry solids. The helix angle of the screw thread, as well as the screw profile along Zones 1 and 2, may also be different. The granular polymer is transformed into a hot melt through the shearing action between screw and cylinder. As mentioned elsewhere in the article, most of the energy for this heat-up of the polymer to the melt stage is supplied by the drive motor. Once the granular polymer is transformed into a hot melt, the effective output rate of an extrusion screw can be expressed as follows:

Output=Drag Flow—Pressure Back Flow—Leakage Flow.

Drag Flow

This is the forward motion of the material produced by the sliding action along the helical channel of the screw relative to the inner wall of the extrusion cylinder. Drag flow is independent of compound viscosity. It is the flow to be expected from an extruder without any die restriction.

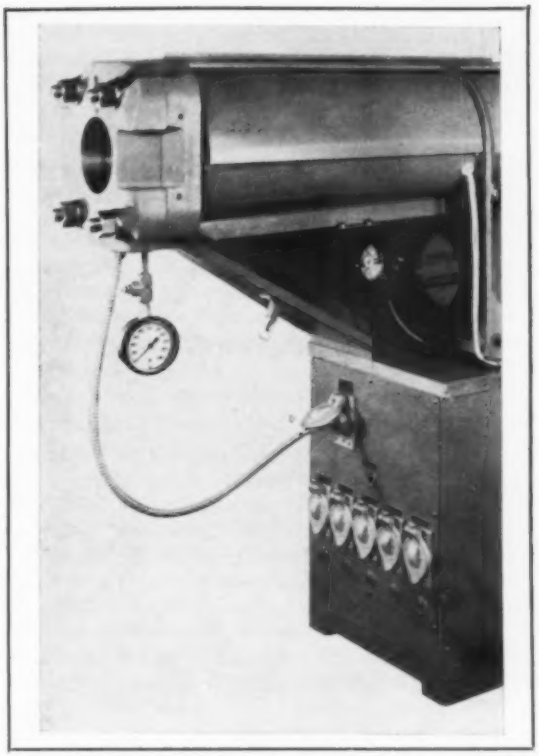


Fig. IV. Front end of extruder with outer guard removed. Note pressure gage, stock thermocouple and watertight receptacles, head heaters, and thermocouples.

Pressure Back Flow

This is the component opposing the drag (forward) flow and is caused by the die restriction. This means: the smaller the die orifice, the greater the back flow component. The term "pressure back flow" is not exactly descriptive of what goes on in the screw channel. It should be termed, the "component opposing forward flow," since the material does not flow back in the screw channel. Pressure back flow exerts a negative influence on the extruder output rate. It is inversely proportional to both the viscosity of the compound and the length of the screw. Therefore, the longer the pumping (metering) section and the higher the compound viscosity, the lower the pressure back flow will be. Pressure back flow is also directly proportional to the channel depth of the screw. This shows the importance of channel depth of the metering section. Old fashioned "deep" screws, such as those frequently used in the rubber industry, are completely unsuitable for plastics extrusion. Mechanical precision of channel depth is important to guarantee uniform output. Therefore, good extrusion screws are concentrically ground between their outside diameters and their channel roots.

Leakage Flow

This is the flow across the lands of the screw thread

along the small clearance necessary between screw outside diameter and cylinder inside diameter. This flow is caused by differential pressures across the screw threads. It has a negative influence on the output rate of the extruder. This negative effect is at a minimum with highest viscosity, widest screw thread lands, and the longest metering section. Here, again, one can see the importance of good workmanship and proper choice of metals for screw flights and cylinder inside surface. The clearance between screw flight land and cylinder wall must be maintained at a minimum to assure good production. Other mechanical and torque requirements for extruder screws are discussed elsewhere in this article.

Stock Temperature

The stock temperature in extrusion blow molding is of great importance and must be controlled and maintained. Stock temperature in extrusion is determined only to a minor extent by the metal temperature of the extrusion cylinder. Heat energy is transmitted into the plastic material mechanically through the shearing action between screw and cylinder. Therefore, most of the energy to melt the polymer is supplied by the drive motor. Screws should be designed to permit mechanical heat-up of the polymer without overheating the material.

The stock temperature range for a given polymer is broadly established by the proper combination of screw channel depth, channel depth ratio (compression), and screw channel length. The desired stock temperature can be established and controlled in varying screw speed and head pressure. Poor stock temperature is measured and indicated by means of a thermocouple immersed in the melt stream (See Figs. I, VI).

With most materials, higher stock temperatures produce a blow molded article with a better finish, and with better physical and mechanical properties. The parison, however, has a tendency to neck down (draw) towards the die because of the gravity pull. In a longer parison, this effect is more pronounced than in a shorter one. Higher stock temperatures also require a longer cooling cycle and cause more shrinkage.

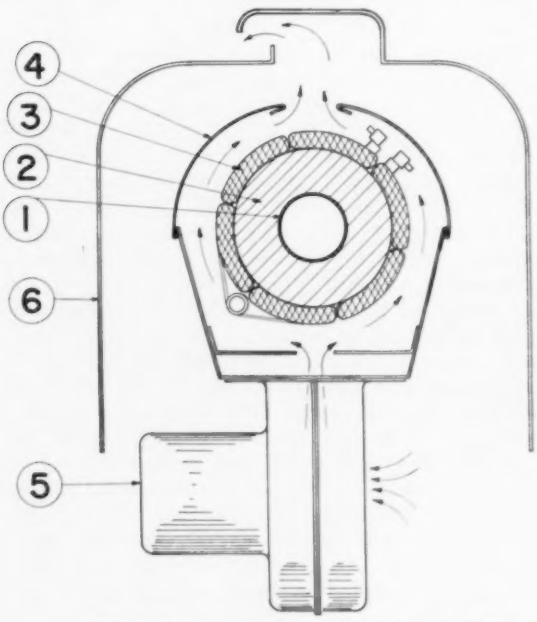
Lower stock temperatures permit easier shape holding of the parison, shorter cooling cycles, and less shrinkage. Too low a stock temperature causes a nonhomogeneous hot melt, and inferior mechanical and physical properties for the finished product. It can also impair good sealing along the pinch off areas.

It is desirable, therefore, to extrude a parison with the lowest possible stock temperature that still permits good finish and good physical and mechanical properties for the end product. An extruder for blow molding must be designed to deliver an extrudate with a relatively low stock temperature and at high production rates. This necessitates a deeper screw rotating at a slower speed. A given horse power necessary to extrude at a high production rate but at slower screw speeds requires accordingly higher torque ratings for the machine.

In other words the total horsepower (output) capacity of an extruder is determined by the maximum torque which the screw can transmit at the speed range necessitated by the required stock temperature.

Extrusion Pressure

When stock temperatures are relatively low, the compound viscosity is higher. This results in high working pressures and the extruder must be designed to operate at these pressures. An extruder suitable for blow molding must, therefore, be equipped with a thrust bearing assembly having an adequate service life at



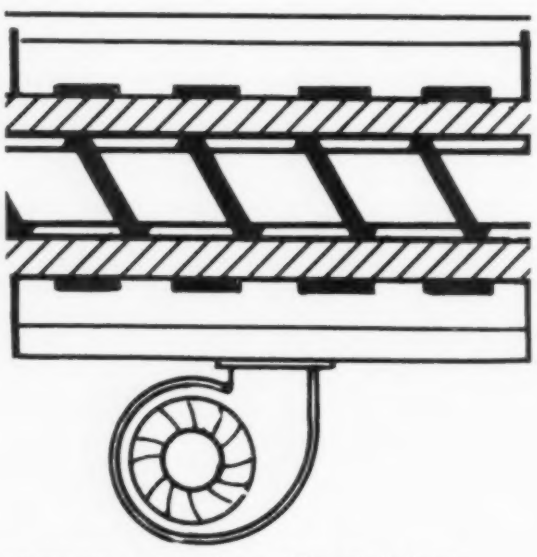


Fig. V. Sectional view of extrusion cylinder, heating and cooling system: 1.—Integrally-cast Xaloy cylinder lining, 2.—Heavy alloy steel cylinder, 3.—Ceramically insulated heaters in aluminum sections, 4.—Innerguard for air circulation, 5.—Centrifugal blower, and 6.—Removable outer guard.

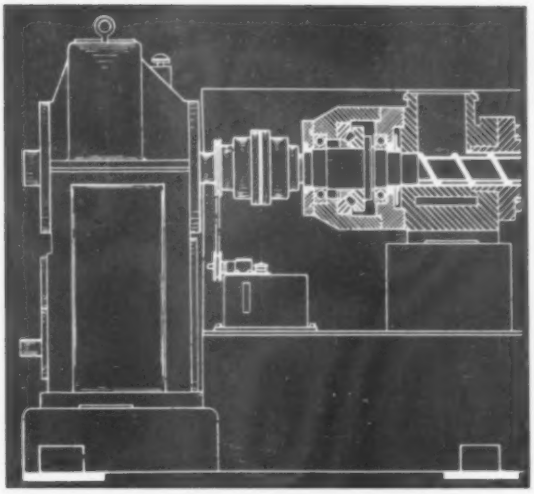


Fig. VI. Typical thrust assembly and flexible coupling.

5,000 psi working pressures. Working pressures are indicated by a pressure gage (See Fig. I, V). The extruder should be equipped with a hard surfaced screw made of alloy steel which has high torque and fatigue resistance. The cylinder must be heavy enough to operate safely over long periods at high working pressures. The extrusion head and gate assembly must also be designed for high pressure operation (See Fig. IV).

Controlled Extrusion Pressure by Valving

Increased head pressure improves extruder performance and mixing efficiency of the screw. This results in a more uniform and homogeneous extrudate. It affects especially the uniformity of stock temperature. Increased extrusion pressure can be obtained by fixed orifices or restrictions, by screen packs, or by an adjustable valve. Screen packs develop a relatively low, non-adjustable pressure which varies during production in an uncontrollable fashion by clogging. Pressure increase with a fixed orifice or restriction is frequently satisfactory, but lacks versatility. The best solution is, no doubt, an adjustable valve or orifice between the head of the extruder and the die (See Fig. I, IV). This would permit instantaneous adjustment of a wide range of controllable pressures. Increase or decrease of extrusion pressure also permits adjustment and control of stock temperature at a given screw speed.

Valving allows the use of a somewhat deeper screw, since increased pressure increases residence time in the extruder. The lower shear rate and mixing action of a deeper screw can thereby be increased effectively. For blow molding extrusion, valving permits the use of a relatively deep screw with low shear rate. Material, therefore, can be extruded at low stock temperatures. The extrusion pressure and shear rate can be adjusted just high enough to obtain a good homogeneous extrudate at the lowest possible stock temperature. Pressure adjustment and increased screw speed make possible high quality extrusion at full extruder output. The only limiting factor is the available horsepower.

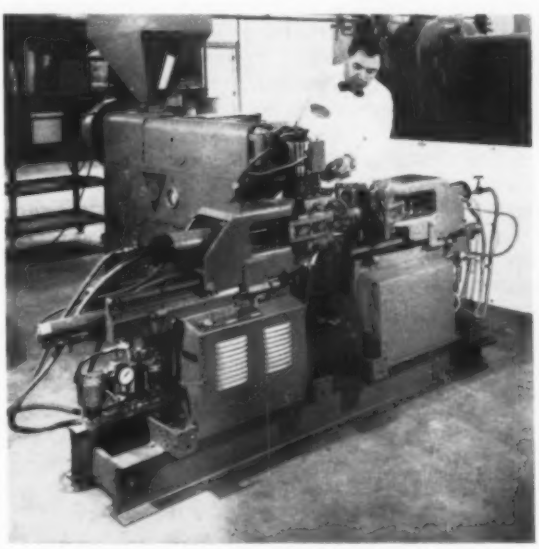
It is readily seen that, with adjustable valving, one can choose and easily reproduce the most favorable extrusion pressure in order to guarantee a uniform, homogeneous, well plasticated parison.

Heating and Cooling

Before startup, a thermoplastics extruder must be preheated to its approximate operating temperature. This is done by steam, circulating oil, or direct electric heat. The heating system must automatically hold its temperature at the preset level. In steam heating, this is done simply by pressure control. Steam not only heats, but is also able to remove excess heat. Steam heated machines are rarely used today because the temperatures necessary for extrusion of modern polymers require a very high steam pressure. Oil heated machines have also lost their popularity during the last fifteen years. Oil presents heat transfer problems at higher temperatures, and gumming necessitates much maintenance.

Direct electric heat is generally used today, especially on the smaller extruders used in blow molding. It is clean, efficient, and easily controlled. The shortcomings and replacement problems caused by mica-insulated heating elements have been overcome by the use of ceramic-insulated heating elements. These heating elements have a very long life and have given excellent results in the field.

There are several design concepts incorporating ceramically-insulated heaters. In one, heaters are cast directly into aluminum sections which conform to the outside of the cylinder. These sections are provided with inner or outer finning or ribbing to circulate cooling air when required. The shortcomings of such designs lie in the considerable mass of aluminum which has to transfer the heat to the steel cylinder by conduction. Since aluminum has a higher thermal expansion rate than steel, even the most precise machining does not guarantee good and regular contact between



Combination extruder—blow molding set up.

All diagrams and photographs courtesy of Prodex Corporation.

the aluminum and the steel. During heating, the aluminum expands away from the steel and causes air gaps which act as thermal insulators, leaving few contact points to conduct heat into the extrusion cylinder. This could cause hot spots.

Fortunately, most of the energy required to heat the plastic is supplied by the drive motor. We maintain that it is not the cylinder heaters, but the screw geometry and screw speed which determine the actual polymer stock temperature. A very good design concept was introduced recently in which a ceramic-insulated heater is mechanically embedded into a number of small aluminum sections. These sections conform to the periphery of the extrusion cylinder and act quite favorably in their aluminum to steel contact. There are a number of these aluminum sections used circumferentially in each zone, each representing only a small volume of aluminum (See Fig. V).

Heater wattage density per square inch should be as low as acceptable for production requirements. Lower wattage density supplies heat more gradually to the extruder since the heater temperature itself is lower.

It has been stated that induction heating gives higher output rates. This is certainly *not* so in any extruder which has a reasonably well designed screw. It must again be pointed out that the extruder could be preheated by any method: oil, electricity, induction heating, or even by a torch, and still the stock temperature of the hot melt will not be determined by the steel temperature of the cylinder, but by screw geometry, screw speed, and head pressure. The only functions of the heating system are to heat up the machine, to make up for radiant losses, or to help the screw with the minor amount of energy which can possibly be transmitted by direct conduction.

Cylinder cooling in an extrusion machine is desirable. It permits rapid cooling of the machine after shutdown, and the removal of excess heat from the steel cylinder. Such heat is frequently caused by a screw which is too shallow and works the polymer excessively. This is often referred to as "friction heat." Automatic control of cooling by three-way controllers is the most convenient method.

Manually controlled cooling is used frequently, since it saves money in the original machine purchase. Air cooling is also widely used because it is clean and easily maintained (See Fig. V). The amount of heat removed by centrifugal blowers is largely satisfactory to compensate for acceptable compromise in screw design. Self contained liquid cooling systems are also available, but require a somewhat higher capital outlay. They remove energy in a very uniform fashion along the whole surface of the controlled cylinder zone. Direct water cooling through spiral coils in the cylinder is not recommended in spite of its low cost. Cold water entering these cylinder coils causes considerable thermal shock. The water converts to steam along the length of the coil, causing temperature differentials as high as 40° F. within the same zone.

Instrumentation

In order to assure easy reproducibility and continuous observation of extrusion conditions, it is necessary to have good instrumentation. The importance of the interrelation between stock temperature, extrusion pressure, screw speed, and horsepower rating has already been pointed out. Therefore, it is obvious that the most important instruments of the blow molding extruder are: the stock temperature indicator, the head pressure gauge, the screw speed indicator (tachometer), and the motor load indicator (wattmeter or ammeter). They should be mounted in such a fashion that they can be easily observed by the machine operator during blow molding production.

Good instruments which guarantee precise temperature control of extrusion head and die are also necessary. Cylinder heating and cooling has been discussed above. The most practical instruments for automatic control of heating and cooling are three-way controllers. Ammeters in each heating circuit are advantageous, since they permit easy detection of partial or total failure of a heating circuit.

At this point, it should be repeated that the temperature of the extrusion cylinder is, in most cases, not the same as the polymer temperature. Thermoplastics are poor heat conductors. It is difficult, therefore, and takes considerable time to heat them to operating temperature by conducted heat. In a plastics extruder, even at relatively slow running speed, not more than 20% of the necessary heat-up energy is supplied by conduction; in modern machines, considerably less. The main function of cylinder temperature controllers is to permit preheating, or cooling down, of the machine to operating temperatures; to hold the temperature at the operating level in compensation for heat losses; or to remove excess heat. Operating temperature and stock temperature, however, are largely determined by the screw geometry and the speed at which the screw operates.

—THE END

Boat passes severe tests

An all-plastic, 40-foot utility boat, fabricated of fiberglass-reinforced, fire-retardant polyester laminate, withstood six and eight foot waves for 15 minutes without damage. The boat is built from Hetron 92 resin, a product of Durez Plastics division of Hooker Chemical Corp., by Chance & Associates, Inc., Waldorf, Md.

The hotbench test method for determining gelation and fusion characteristics of plastisols

Determining temperatures of various states of plastisol gelation and fusion, and their time-dependency.

J. A. GREENHOE*

In industrial practice, plastisols are fused at oven temperatures which differ as much as 200° F. from one process to another. The time of fusion, likewise, may vary from as low as 15 seconds to as high as one hour and more. Heat transfer rates through metal molds and through thick plastisol sections, oven design, and other factors often confuse the true temperature and time of gelation and fusion of plastisols.

Previous studies have not adequately separated the effects of time from those of temperature due to the nature of the tests. These tests have been conducted either in air-ovens where plasticizer volatility and poorly controlled heat-transfer rates have confused the results, or in containers of appreciable quantities of plastisol where the slow heat-transfer rates through the plastisol have clouded time-at-temperature determination.

The purpose of this paper is to present a method by which the temperature to attain various stages of plastisol gelation and fusion may be determined at very low time-intervals. In this way, the effect of time at a given temperature is shown. Also, the various stages of plastisol gelation and fusion are given meaning in relation to tensile strength development.

Hotbench Test Method

The Hotbench Test consists in essence of laying down a thin film of plastisol in intimate contact with a hot, smooth surface having a temperature gradient; stripping this film off at desired time intervals; and testing the film for its gelation and fusion characteristics. Heat transfer rates from the hotbench to the thin film are very rapid, and a single length of film which has been treated to a range of temperatures for a given time interval is obtained.

For the data presented here, an Incline Flow Plate manufactured by Castor Engineering Co. was modified by polishing its surface, inscribing 12 lines on it at two-inch intervals along its length, calibrating the pyrometer (from thermocouples embedded in the plate) to read the temperature at the surface of the plate at each of these inscribed positions. The equipment is shown in Figure 1.

A three-inch wide and three-mil thick film of plastisol was drawn down on the strippable paper with a Bird Applicator Blade, and the paper then was laid film-side down on the hotbench. This was done by rolling from the back side of the paper with a hard rubber roller so that a lay-up of hotbench-plastisol-paper was produced. After a given time interval, the paper was stripped from the hotbench. At the lower temperature end of the gradient, the plastisol film has little strength and breaks; the unfused portion remaining on the hotbench, while the portion of the film in various degrees of fusion remains with the paper. This fused film is removed from the paper and the temperature at the various positions on the hotbench are read. The plastisol film takes the impression of the markings on the hotbench surface, so the temperature readings correspond to markings on the film itself.

A brief description of the appearance of the plastisol film after being subjected to a temperature gradient is inserted here for an understanding of the Hotbench Method. At the lowest temperature (about 160° F.), the opaque plastisol is quite fluid. Along the length of the film subjected to higher temperatures, the plastisol becomes higher in viscosity, and reaches a tacky, putty-like consistency which progresses to a dry, crumbly state, and then to a brittle film having some small

* Tech. Service Rep., Opalon PVC, Monsanto Chemical Co., Plastics Division, Springfield, Mass.

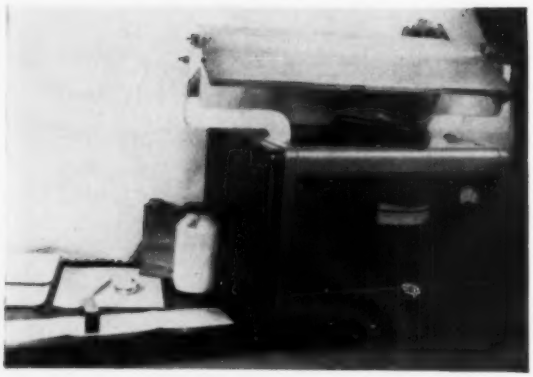


Fig. 1. Hotbench equipment used in the tests.

amount of cohesive strength. This is the point at which the film breaks when it is stripped from the hot end. At successively higher temperatures along the hotbench, the film gains in strength, and loses opacity. At still higher temperatures, the film gains maximum tensile strength, and clarity. Finally, toward the highest temperature end (400° F.) of the hotbench, the film shows high gloss, and some evidence of melting of the fused plastisol.

Discussion of Test

Returning to the test, the solid film in various degrees of fusion was tested for physical-strength development. Small specimens cut from the film at each ¼-inch of length were tested for tensile strength. Figure 2 is a plot of the data obtained from one film prepared at a five-minute dwell time on the hotbench. Also in Figure 2 is a plot of the same measurements taken from separate films prepared in a steam press with water cooling at each of many temperatures. The time interval for the steam press films also was five minutes. The press method was chosen as a method which most nearly approximates the characteristics of the Hotbench Method—rapid application of heat, and freedom from plasticizer volatilization. The two methods can be seen to give approximately the same results. Tensile strength information obtained from the single film with the Hotbench Method has obvious attractions in sample preparation time and in test specimen temperature control.

To further simplify studies of this nature, certain definable transitions were determined in the states of gelation and fusion of the hotbench film. These were found to relate to the tensile strength development of fusion and to the plastisol viscosity rise of gelation. By simple manipulation of the film, six different transition points were discovered. These were given names as follows: "Fluid Point", "Dry Point", "Gel Point", "Haze Point", "Elastomeric Point", and "Fusion Point."

Where the fluid plastisol makes a transition to a dry, putty-like consistency, there is a noticeable loss of gloss and of plastisol mobility. This reproducible transition in state has been named the "Fluid Point." The higher temperature position on the hotbench where the putty-like plastisol changes to a dry-crumbly solid also is easily observed. This transition has been given the name, "Dry Point."

As previously described, the film breaks at a certain point when stripped from the hotbench. At this point, the film exhibits a transition from a dry, friable solid to a brittle film having some cohesive strength. This change in the plastisol is noted as the "Gel Point."

The film on the paper which is removed from the hot end of the temperature-gradient is marked by three additional transitions which may be observed. As the resin is further solvated by plasticizer, resin particle interfaces are lost and clarity begins to develop. This visual change is named the "Haze Point." There also is an increase in film strength and elongation near the "Haze Point" that is noticed readily by a simple manual stressing of the film. This marked increase in film strength development is called the "Elastomeric Point." Finally, the plastisol which has been subjected to still higher temperatures exhibits complete fusion as evidenced by its resistance to disintegration when the film is immersed and stressed in ethyl acetate. This point is called the "Fusion Point."

Although these test methods obviously are subject to operator prejudice, they are reproducible with a skilled operator. Table 1 gives a statistical analysis of each point, with the estimated variances, σ^2, the standard deviations, σ, and the 95% confidence limits, 2σ. Where the variances for each test and time were found to be from the same population, they are calculated as one

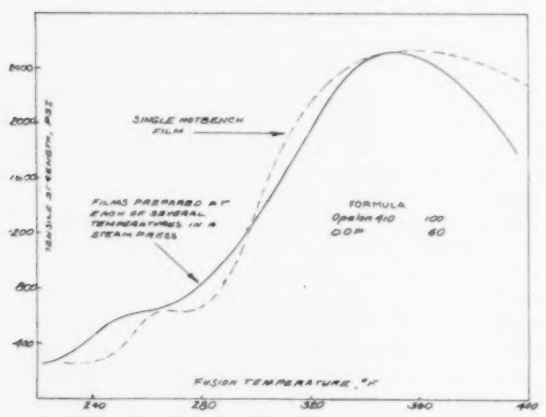


Fig. 2. Plastisol fusion temperature and tensile strength.

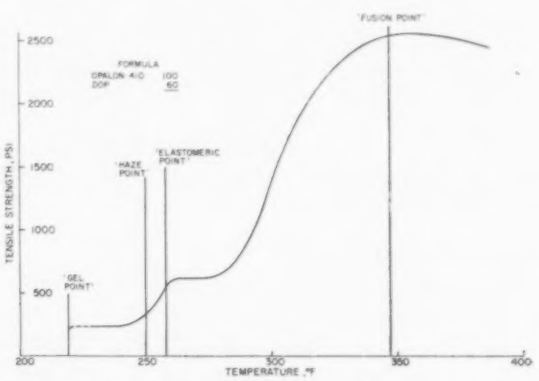


Fig. 3. Hotbench fusion temperatures and tensile strengths.

Table 1. Statistical Analyses* of Hotbench Determinations.

Test Points	Test Dwell Time, Seconds					
	5	10	30	60	120	300
"Fusion Point"			$\sigma^2 =$ 2.86			
"Elastomeric Point"			$\sigma =$ 1.69			
"Haze Point"			$2\sigma = \pm$3.38			
			$\sigma^2 =$ 4.74			
"Gel Point"			$\sigma =$ 2.18			
			$2\sigma = \pm$4.36			
	$\sigma^2 =$ 0.97	3.23	3.36	3.23	5.66	0.40
"Dry Point"	$\sigma =$ 0.985	1.80	1.83	1.80	2.38	0.632
	$2\sigma = \pm$1.97	±3.60	±3.66	±3.60	±4.76	±1.26
	$\sigma^2 =$ 0.074	2.32	1.8	0.42	1.06	1.55
"Fluid Point"	$\sigma =$ 0.272	1.52	0.648	0.648	1.03	1.24
	$2\sigma = \pm$0.54	±3.04	±2.689	±1.30	±2.06	±2.48

* σ^2 = Estimated Variance.
σ = Standard Deviation.
2σ = 95% Confidence Limit, °F.

variance. Within the 95% confidence limits, the error for all points falls with ± 5° F.

Through the use of these observable points which are reproducible within the limits described above, tedious tensile strength measurements and viscometric gelation measurements may now be supplanted by simple transition points on a quickly-prepared hotbench film. This is shown in Figure 3, where a comparison of the hotbench "Gel Point," "Haze Point," "Elastomeric Point," and "Fusion Point" are superimposed on the tensile strength curve obtained from a hotbench film. The "Gel Point" can be seen as the beginning of plastisol fusion or tensile strength development. The "Haze" and "Elastomeric Points" relate to an initial rise in tensile-strength development which occurs after a plateau of low tensile strength. This possibly may represent the solvation of the population of smallest resin particles in the system. The "Fusion Point" marks the complete fusion of resin as measured by maximum tensile-strength development.

In Figure 4, the relationship is shown of the hotbench "Fluid Point" and "Dry Point" to plastisol viscosity by being superimposed on a curve of plastisol viscosity rise with temperature. This curve was obtained by measurements made by the proposed SPI Gelation Test. This test consists of continuously measuring the viscosity of a plastisol with a Brookfield Viscometer while the plastisol is heated rapidly. The plastisol is contained in a small metal tube, the viscometer spindle is centered in the tube, a thermocouple is placed in the plastisol near the viscometer spindle, and the tube is placed in an oil bath at 100° C. Viscosity of the plastisol is plotted against the temperature of the plastisol.

In relation to the gelation curve, the "Fluid Point" occurs at a temperature where the viscosity is rising most rapidly to an infinite value. The "Dry Point" occurs at a temperature just above that at which the plastisol loses its identity as a fluid.

In this way, all of the readily-observed transitions of the hotbench film have proved significance in the plastisol change of state, as measured by other means. The temperature at which these transitions take place may be determined rapidly, and used in place of tensile strength or viscosity measurements to characterize the gelation and fusion of plastisols.

Test Studies

A knotty problem which can be readily studied by this method is the time required at a given temperature to reach any given state of plastisol gelation or fusion.

A three-mil film may be laid down against the hot surface of the hotbench in as little time as one or two seconds, and stripped from the plate in less than one second. The heat transfer rate to the film which is in intimate contact with the plate is very rapid, the heat capacity of the plate in relation to that of the film is very large, and the film is insulated by the strippable paper from ambient room temperatures, so that the film quickly assumes the temperature of the hotbench. By choosing varying dwell times of the film on the hotbench, the effect of time at temperature may be studied.

Figure 5 represents a study of a plastisol subjected to increasing dwell times from five seconds to five minutes. The film displayed complete fusion in as little time as five seconds. The portion of the film subjected to any temperature below 347° F. did not display complete fusion in times as long as five minutes.

From this plot of fusion temperature against time, it is apparent that this temperature is not time-dependent,

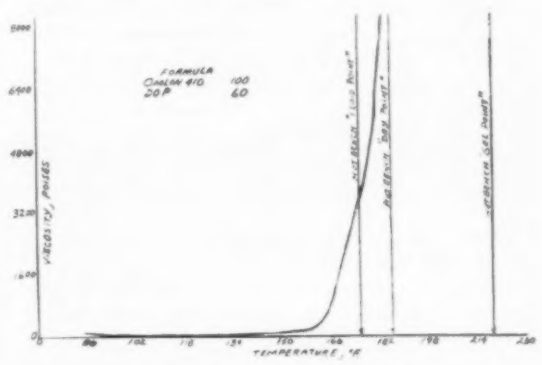


Fig. 4. Plastisol gelation with temperature.

Table 2. Plastisol Gelation and Fusion Properties Produced by Various Phthalate Plasticizers*

Phthalate Plasticizers	Fusion Point	Elastomeric Point	Haze Point	Gel Point	Dry Point	Fluid Point
Di n-butyl	331	241	191	171	—	—
Di n-amyl	315	246	228	191	—	—
Butyl benzyl	346	248	248	198	162	—
Di n-heptyl	347	261	230	207	172	—
Di capryl	343	275	259	223	228	162
Di isooctyl	345	268	248	221	209	162
Di (2-ethyl hexyl)	347	256	250	222	197	176
Di n-butyl isodecyl	354	261	243	198	181	—
Di (2-ethyl hexyl hexa hydro)	—	280	270	239	228	185
Di n-octyl decyl	342	275	248	223	214	—
Di isodecyl	361	289	270	256	253	190

* By five-minute hotbench determinations, °F.

and that the heat-transfer rate from the hotbench to the film at this temperature is rapid enough to be a negligible factor in the results. The "Elastomeric Point" likewise is not time-dependent. The other points of gelation and fusion show some time-dependence up to 30 seconds, but very little at longer times.

From this data, the conclusions may be drawn that once a plastisol has reached the ultimate temperature to which it is being heated, the physical properties of the platisol change very slowly. Certainly, the solvating power of the plasticizer used in the plastisol will affect this rate of change—especially at the low temperature transitions.

In the studies presented so far in this paper, only one plastisol formula has been used—the simple test formula of 100 parts of Opalon 410 vinyl paste resin and 60 parts of dioctyl phthalate plasticizer. By means of the Hotbench Test, the effects of plastisol formulation variables on gelation and fusion also may be studied easily. One of these variables, plasticizer concentration, is presented in Figure 6 where the temperature to reach the hotbench transition points is plotted against parts DOP per 100 parts Opalon 410.

Fusion takes place at about 345° F., regardless of the plasticizer concentration. The transition points, aside from the Fusion Point, occur at increasingly lower temperatures as the resin concentration in the plastisol is increased. This also is evident from consideration of the mechanism of plastisol gelation. Resin particles are swollen by plasticizer until the particles touch each other and become closely packed, thus reducing the fluidity of the system. At high resin concentrations, the resin particles already are closely packed, so that the amount of swelling which occurs at lower temperatures is sufficient to solidify the plastisol.

Many tests for plastisol fusion have been used which do not actually measure the temperature at which ultimate tensile strength development takes place. The tests for clarity, gloss, and even gelation have been interpreted to indicate plastisol fusion temperatures. A study of another plastisol formulation variable—the paste resin itself—discloses the error in considering such tests as indications of relative fusion rates or temperatures.

In Figure 7, a comparison is made between six competitive vinyl paste resins. This Figure demonstrates that the resin contribution to the temperature of complete fusion cannot be predicted from the temperature at which some prior state of physical development occurs in a plastisol. Nor in a comparison of paste resins can any one hotbench point be extended to indicate the relative behavior at any other point; each point

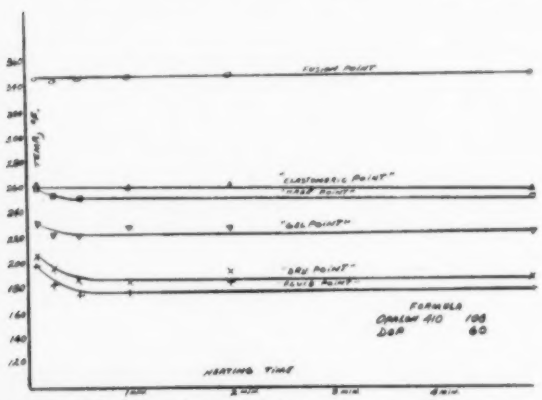


Fig. 5. Hotbench gelation and fusion test time at temperature.

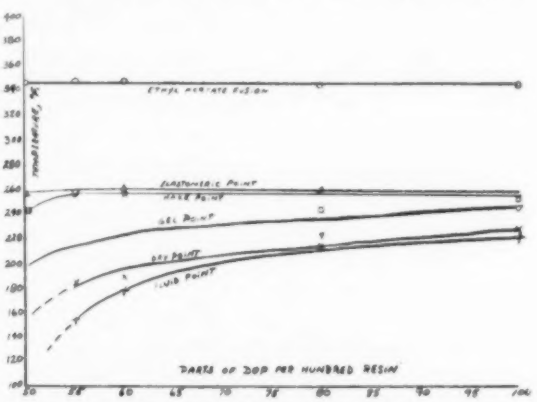


Fig. 6. Plastisol gelation and fusion characteristics as a function of plasticizer concentration.

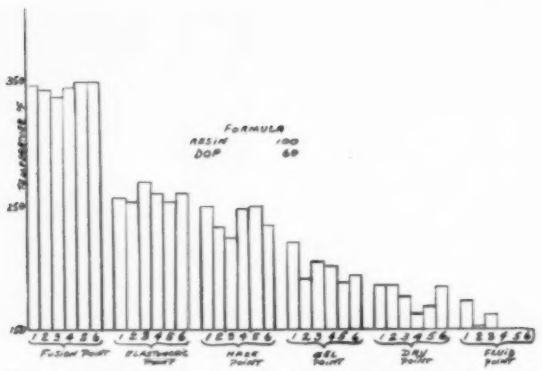


Fig. 7. Comparison of six paste resins—hotbench gelation and fusion.

has its own significance.

In industrial practice, sometimes erroneous criteria are applied to judge plastisol fusion. The fusion temperature or rate of a plastisol may be judged in comparison to a control plastisol by its rate of gelation as measured by viscometric methods. Another practice is to relate the fusion of a plastisol to the degree of clarity it develops, or to a film strength less than it would have at complete fusion. Figure 7 serves to demonstrate the error in such practices.

The plastisol formulation ingredient which has the greatest influence on the gelation and fusion of platisols is the plasticizer. In Table 2, the hotbench gelation and fusion temperatures are given for a list of phthalate ester plasticizers. The plasticizers are listed in order of increasing molecular weights. In general, plasticizers which fuse at a low temperature also display low temperatures at all points of gelation and fusion.

Plastisol Formulation

The temperature of complete fusion can be altered very little from the common rule-of-thumb fusion temperature of 350° F. Considering those systems of phthalate plasticizers which would be used commonly in a plastisol—those of molecular weight from an equivalent of dihexyl phthalate to that of didecyl phthalate—the fusion temperature varies only 18° F., or approximately ± 10° from 350° F.

Since the ratio of resin-to-plasticizer does not affect the fusion temperature, and common paste resins differ little in fusion temperature, plastisol formulation to achieve significantly low fusion temperatures appears to be very difficult. If less than complete fusion is acceptable, formulating from a consideration of the "Elastomeric Point" values of the resins and plasticizers offers greater promise.

Where the gelation characteristics of a plastisol are to be altered, the choice of plasticizer is very important. The "Dry Point" temperatures of the common phthalates have a range of 91° F.

In the rotational molding of plastisols, the "Fluid Point" can find application in discovering the temperature at which the vicosity becomes too high for ready flow in the mold. In slush molding or hot-dip applications, the "Dry Point" may serve to indicate the temperature at which slippage of partially gelled plastisol would not occur. The "Gel Point" is useful in those applications where partially fused plastisol must be handled before complete fusion is accomplished.

The "Haze Point" can be used where the clarity of an unpigmented plastisol is of prime consideration. The "Haze Point" is useful, along with the "Elastomeric Point," for determining the temperature at which useful tensile strength below that of ultimate tensile strength is developed. This test could find importance in formulating for processes and end-uses where oven design is inadequate for complete fusion, and where something less than complete fusion (however undesirable) may be tolerated.

Conclusions

In summary, the Hotbench Test which has been described above is a simple and comprehensive means to characterize the change of state of plastisols on heating. This test can be used to augment and supplant existing tests now used in the plastisol industry.

—The End

Coatings forecast

Production of synthetic resin protective coatings, including alkyds, urea and melamine, phenolics, polystyrene, vinyls, polyurethanes, and polyethylene, epoxies, polyamides, and fluoroethylene could break one billion pounds by 1964. This forecast is based on the findings and analyses to date of James Margolis, Chemical Marketing & Research Co., in a multiple sponsored survey of coatings in major consuming industries.

According to statistics, the major consuming industries for coatings are growth areas in the economy, but, with the exception of packaging, not explosive growth areas. For example, more than five million tons of metal are expected to be consumed for metal cans this year, and by 1965 this figure is expected to climb to near six million pounds. This increase will have a bearing on the vinyls, acrylics, epoxy phenolics, and epoxy ureas used to coat metal containers. The automotive industry, a high volume consumer of alkyd, acrylic, and vinyl resin coatings, may produce ½ million more passenger cars in 1965 than at present. Household furniture and appliance sales are expected to reach record highs.

More than half of the total coating resin production is consumed by the construction, transportation, and packaging industries. Coating resin production has not shown a dramatic rise during the 1950's partly as a result of the growth patterns of its end use industries. Assuming that these patterns do not change significantly, the expected 45 million-pound estimated average increase in production would have to receive its impetus from new technical and marketing developments. Recent developments, such as polyethylene-coated paper packages and the acceptance of polyurethanes for electrical, industrial, construction, transportation, and furniture application will contribute significantly.

ENGINEERING FORUM

How close your tolerances?

Compression & transfer molding

Edited by: PAUL E. FINA*

When a molder examines a drawing, he will inevitably look for the dimensional tolerances specified. Should he consider them too close, his immediate reaction is to strive for looser tolerances. He will remember such past problems as machining the molding dies to dimensions, controlling molding conditions and techniques, obtaining consistent molding compounds, and determining the possible variations in dimensional stability of the molded part. A molder is justified in seeking more "open" tolerances, because the final responsibility of molding a part within tolerance is his!

Many a potential plastic product has been rejected on the basis of tolerance requirements. Let us consider some of them. Many questions can be asked: Can anything be done to improve control? Can molding variations be reduced? Is it practical to "inspect away" parts not within tolerance? Can the material supplier be forced to furnish consistent compounds? Will the tool maker be able to improve his mold-making techniques so as to meet rigid specifications, but not charge more for the tool? Will it ever be possible to predict the final dimensional tolerances of a molded plastic part? These questions raise the issue. The answers are harder to come by.

Factors Affecting Tolerances

Molding Dies

1. Type of metal used and how produced. Steels, aluminum, and cast iron. The density, hardness, and thermal expansion of the metal are important considerations in die design.

2. Type of mold design—positive, semi-positive, etc.

3. Mold construction—use of die sets, channeling for heat (electrical, steam, or hot-oil), integral fit of parts, knockout system, draft considerations, mold wear, mold misalignment, etc.

4. Method of machining—hobbing, milling, grinding, shaping, etc.

5. Post treatment of molding die—hardening, chrome plating, etc.

Of the above factors, mold design can produce the greatest variation in dimensional control during molding. The shrinkage data furnished by the material supplier is usually based on positive-type molds. Other mold designs (flash, plunger, etc.) can produce shrinkages which differ radically. Shrinkages are always given in terms of a cold mold—cold piece, using an ASTM die of specified tool steel. Thus, in regard to their effect on tolerances, different kinds of mold-die metals may result in different final dimensions. As an example, aluminum expands more under heat and consequently may produce a larger (or smaller) part than expected. The coefficient of thermal expansion of metals must be considered.

* Dr. of Sales Engrng. The Fiberite Corp., Winona, Minnesota

Molding Condition

1. Pressure to mold. A fully molded part using minimum pressure will be smaller than a part molded at maximum pressure. However, the "hot-to-cold" molding shrinkage of a part made larger due to using higher molding pressure is the same as for the smaller part molded at lower pressure.

2. Mold temperature. The effect of die temperature alone is not a large factor in dimensional control; but coupled with its effect on cure, molding pressure, flow, etc.; can throw tolerance allowances considerably out of range.

3. Preheating of molding compounds can play a big role in dimensional control. A "room-temperature" loaded material should give more shrinkage than a material loaded hot. This is true for both type loading and use of preforms.

Molding Techniques

Molding techniques employed to alter shrinkages are many. Below are several ways: (Note: Techniques listed below are not applicable to all dimensions, but for outside dimensions shrinking towards the center. An inside hole may close in or open up depending on the mass surrounding it).

TECHNIQUES FOR MAXIMUM SHRINKAGE (COMPRESSION MOLDING). Use: minimum weights of material, to the point of shorting; softer flow materials, to the point of no blisters; minimum molding pressure, to the point of just filling; minimum cure, mold temperature should be to high side; minimum to no preheat of material; and minimum time to close mold without damaging it (the converse may be true with certain mold designs).

Do not predry material; however, conditioning is often necessary for better electrical properties. In extreme cases, completely close the mold with minimum pressure possible. If degassing is necessary, breathe or de-gas the mold and then close again at reduced pressure. Cure out on this lower pressure. To control for extreme shrinkage, use landing pads and keep the pressure off of the part during cure. Clearance in the mold between punch and cavity will vary shrinkage; the more clearance, the more shrinkage.

TECHNIQUE FOR MINIMUM SHRINKAGE. Use maximum weight of material possible (this is not true for mold designs allowing free escape of material); hard flow material (here, more molding pressure might be required); maximum molding pressure; and maximum cure and minimum mold temperature (for phenolics, about 320° F.). Preheat material as much as possible without pre-curing. Allow maximum time for closing the mold. (Again, watch out for setting up or pre-curing of molding compound, and avoid escape of material).

If possible, pre-dry material in an oven (140°-150° F. for 4-8 hours). Drive out all moisture—the amount depends on original volatile content. For the least shrinkage, overload enough to keep pressure on the part, but not enough to keep the mold open. Uneven overflow of material will cause variable density and, consequently, irregular shrinkage. Clearance in the mold between punch and cavity will vary shrinkage. Minimum clearance assists in minimum shrinkage. Once a technique is established, it should be perpetuated.

Material Control

Whenever possible, materials should be checked out by the molder before using. If the molder does not have the facilities to evaluate material quality, then his specifications, when ordering, should be listed. A careful purchasing agent will include the following material specifications: type of material, color, form, and bulk factor; resin solids content (standardized in most cases); volatile content (including moisture); thermoplasticity or plasticity (soft to hard flow); method of molding; and type of mold design.

In my July column entitled "When Quality Is More Important Than Price", I reviewed means of controlling materials and reasons. Now, I would like to present some methods for testing materials.

Applicable Test Methods For Molding Compounds

Total Volatile Content—Including Moisture

Apparatus required would include an analytical balance, a desiccator charged with anhydrous calcium sulphate, porcelain crucibles (size 1) with covers, and a forced air oven (vented) set at 305-325° F.

The procedure involves obtaining the tare weight of a clean, dry crucible and cover which have been heated for 10 minutes in a muffle furnace at 1,000° F., and cooled in the desiccator. Weigh the sample of material to be tested in the crucible, including the cover. Do not fill the crucible more than ½-⅔ full. Sample weight will depend on the material's bulk factor.

Place the cover on the crucible at a slight angle, leaving an escape gap for volatiles. Place in the circulating air oven for 15 minutes, remove, and cool to room temperature in the desiccator. Remove the crucible at this point and weigh immediately. All weighings are carried out to 0.001 gram.

CALCULATIONS. Total volatile content, per cent = $\frac{W_1 - W_2}{W_1} \times 100$. Where W_1 = original weight of sample, W_2 = final weight of sample.

NUMBER OF TESTS. Preform three testings on samples selected at random from each production lot of material. Report the average of the three values.

Thermoplasticity, or Flow (A.S.T.M.)

Apparatus required includes a surface pyrometer, cup mold (as specified in A.S.T.M. Method D731-55T), hydraulic press with automatic timing device, mold heating system, automatic pressure control, preform mold, and an arbor press.

The procedure involves setting the mold temperature at 325-335° F., setting the pressure system to give required maximum pressure on the mold (6 tons for impacts), and setting the timing device to start when pressure is applied to the material and stop when specified "flash" thickness is reached (e.g. 0.026 to 0.030 inch for impacts). Determine the charge weight and molding pressure in accordance with the above A.S.T.M. method. Weigh the sample to be tested, and preform the charge in a 1½-inch diameter mold using the arbor press. Without preheating the sample, determine the flow in seconds required to close the mold as indicated by the timing device.

NUMBER OF TESTS. This is an in-process control procedure, as well as a test on the finished material. Two flow values are run on a composite sample of each lot, and both are reported. There are several types of plasticity measuring devices. In the more free-flowing compounds, the above method may not be sensitive enough. Consult your supplier for advice.

Post Molded Shrinkage or After Shrinkage

Every molded compound has a degree of after shrinkage. Melamines and premix polyester types usually run highest, with certain phenolic-glasses and epoxies probably runing the lowest. Much can be done to stabilize each type of compound by altering the composition. Certainly, to obtain the optimum quality, a molder should plan for minimum shrinkage.

Continued shrinkages under normal operating conditions are evident in many compounds such as, melamines and one-step phenolics (the author prefers to use the term one-step to one-stage to avoid confusion with a-stage, and c-stage). Post shrinkage can be tested out in proprietary laboratories, and charts are available from material suppliers.

Some materials almost complete their shrinkage in the mold during cure (hot shrinkage); others do not shrink and may even grow during cure in mold (causing a binding on knockout). The latter shrink after cooling. When interpreting shrinkage data, potential post mold shrinkage should be kept in mind.

Additional shrinkage at high operating temperatures

is a concern. Molded parts may have residual volatiles, uncured areas from under heating, and may emit additionally-created volatiles or gases. For best results, equivalent samples molded under the exact conditions of a controlled molding compound should be tested in simulated operating conditions. A heat-test program may be accelerated, but often this does not give the true results.

Finally, it should be mentioned that when a molded item is to operate in a special atmosphere or is subject to contact with certain liquids, there may be a definite deviation in a shrinkage (or growth) pattern. Many a molder has neglected to check out dimensional stability under such conditions as hot oil, high humidity, thermal shock, and chemical vapors.

General Observations

In general, molders often set up a blanket tolerance or allowance for all dimensions in a molded part. This is a mistake! Each dimension should be examined on its own and a tolerance established for that dimension. Horizontal and vertical shrinkages are different. In plunger molding, shrinkage may vary in different areas.

Flow patterns during material movement can affect shrinkage. The depth of draw plays an important role. Shrinkage varies from top to bottom of a draw because thermosetting materials do not transmit pressure as liquids do. A pressure drop is difficult to avoid. The further away from the source of pressure, the more the shrinkage. Loading technique can produce a change in a dimension. Understanding the effect of die design and part design requires careful study.

Often a molder is forced into a low grade, low cost material to meet a price. With the material doubtful as to dimensional stability, inevitable failure is in the offing. It is better to redesign, perhaps by using a better grade, higher priced material. Usually, there are other ways of reducing costs such as decreasing the thickness of a molded piece. Thinner sections shrink less. Should the strength be affected, use a stronger or higher impact material. Another means of reducing shrinkage would be to use a low shrinkage mineralized material. Whenever possible, reduce wall sections to reduce costs rather than use a low cost, unstable material.

Conclusion

A few studies have been offered to indicate tolerance or shrinkage variation. Predictability, material control, maintenance of molding conditions, and precision molding techniques are all within the province of a molder. The molder who holds his tolerances close, can expand his horizons.

A TOLERANCE STUDY. Special study on a 7.874 by ¾-inch thick part using a two-step, fabric filled compound, compression molded at a constant mold temperature of 335° F.

Cure time, minutes	Plasticity (flow)	Preheat temp. (preform)	Mold pressure, psi.	Tolerances, inch/inch
4	hard	240° F.	4,800	within 0.00030 in.
5	hard	240° F.	3,700	" 0.00050 in.
	hard	200° F.	3,700	" 0.00080 in.
	medium	200° F.	3,700	" 0.00055 in.
	medium	150° F.	3,700	" 0.00055 in.
6	hard	240° F.	4,800	" 0.00030 in.
	hard	200° F.	4,800	" 0.00010 in.
7	medium	150° F.	3,700	" 0.00055 in.
4-7	medium	150° F.	3,700	" 0.0014 in.
	hard	240° F.	4,800	" 0.0105 in.

From the few inconclusive values above, it is clear that optimum values can only be determined through actual molding trials on each part. Definite standards are possible, but more studies are needed. Values were taken directly from the cold part after 20 days, using special inspection equipment for accuracy. The results are actual; no adjustment of tolerance values was made.

AFTER SHRINKAGE STUDIES. Conditions: 40 days at room temperature. Materials were molded conventionally with no special controls. Specimens ½- by ½- by 5-inch bars—positive molds. Phenolic two-step-soft flow; additional shrinkage—0.0015 in./in. (average). Phenolic two-step—hard flow; additional shrinkage—0.0004-0.00007 in./in. (average). Phenolic one-step—soft flow; additional shrinkage—0.0025 in./in. (average). Melamine—medium flow; additional shrinkage 0.0006 in./in. (average). Melamine—mineralized—very soft flow; additional shrinkage—0.0012 in./in. (average). Note: the above "additional" shrinkages are not to be taken literally but, as indicated, are for study purposes only.

AFTER SHRINKAGE STUDIES. Conditions: conventionally molded parts. Specimens varied, with ½-inch thickness being the average. Continuous dry oven heat at 250° F. was standard.

Note: This study should be of great interest to the industry. It shows that every material should be checked out when operating conditions are above normal. Notice the high shrinkage of the one-steps occurring within the first week, but the leveling off that occurs. Parts with varying wall thickness usually warp.

Material	Initial Shrinkage	After 140 hrs.	After 375 hrs.	After 500 hrs.	Total additional after-shrinkage
Phenolic-Asbestos, 1-step	0.003 in./in.	0.002 in./in.	0.0007 in./in.	0.0003 in./in.	0.003 in./in.
Melamine-Fabric	0.003 in./in.	0.008 in./in.	0.003 in./in.	0.00013 in./in.	0.0124 in./in.
Phenolic-Nylon, filled, 1-step	0.010 in./in.	0.004 in./in.	0.0013 in./in.	0.0013 in./in.	0.0066 in./in.
Phenolic-Sisal	0.0053 in./in.	0.0007 in./in.	0.0007 in./in.	0.0007 in./in.	0.0021 in./in.
Phenolic-Glass	0.0011 in./in.	0.0003 in./in.	0.0002 in./in.	0.0001 in./in.	0.0006 in./in.
Phenolic-Asbestos, 2-step	0.0016 in./in.	0.0005 in./in.	0.0003 in./in.	0.0002 in./in.	0.0010 in./in.
Phenolic-Fabric, 2-step	0.0024 in./in.	0.0007 in./in.	0.0005 in./in.	0.0002 in./in.	0.0014 in./in.
Phenolic-Paper filled, 2-step	0.006 in./in.	0.0007 in./in.	0.0006 in./in.	0.0003 in./in.	0.0016 in./in.
Phenolic-Fabric, 1-step	0.005 in./in.	0.0065 in./in.	0.0014 in./in.	0.0004 in./in.	0.0083 in./in.
Phenolic-Cellulose & mineral filled, 1-step	0.0063 in./in.	0.0078 in./in.	0.0003 in./in.	0.0001 in./in.	0.0082 in./in.

—THE END

T. H. Beals

The effect of molding conditions on the color of reinforced plastics moldings

Factors affecting color of parts and their relative importance.

THOMAS H. BEALS*

One of the important attributes of reinforced polyester moldings is their ability to be pigmented to almost any desired color. The demand for items molded to match a specific color sample has increased as more designers take advantage of this attribute.

The color of a molded part is primarily dependent upon the pigment used in the molding formulation. In cases where a very rough color match is desired, the pigment is usually the only factor which needs to be considered during color matching. Where an exact color match is required, the specific molding resin, filler, formulation of the resin mix, and curing conditions to be used in the molding should be maintained in the matching of the color. Often, these initial conditions are varied during the production run of a part without knowing the effect of such variations on the color of the molding. The following investigation was conducted to determine some of these effects.

Experimental Procedure

Two series of panels were molded at each of two pigment levels under a variety of molding conditions. The panels were measured with a General Electric Recording Spectrophotometer equipped with a Librascope Tristimulus Integrator. This instrument determines what an observer with normal color vision sees when viewing the color in average daylight. The results are recorded in terms of the three primaries necessary to describe a color. All test and standard panels were measured relative to the barium sulfate white standard. To obtain the color difference between the test panel and the standard panel, tristimuli values for the test sample compared to those of the standard panel were transformed by means of the MacAdam uniform chromaticity space equation to the single unit, $\Delta\Sigma$. The least visually perceptible difference on this test has been previously determined to be one unit.

* Chemist, Paint Division, Pittsburgh Plate Glass Company Research Center, Springdale, Pa.

Various color pigment pastes were available for this study, but it was felt that the choice of a particular color might influence the interpretation of data. A light grey pigment paste which was not expected to interfere with the effects of the molding variables was, therefore, chosen for this work. The composition of this paste was 39.80% titanium dioxide, 0.06% carbon black, and 60.14% vehicle.

Test moldings were prepared in a chrome-plated matched die mold which was closed to stops. Panel size was 12 by 12 by 0.1-inch. The die was electrically heated and a surface pyrometer was used to control the molding temperature to ±4° F. All panels were prepared using two pieces of two-ounce 219B mat. No mold release agent was used.

Filler content, catalyst content, molding time, and molding temperature were evaluated in the first series of moldings. This experiment was statistically designed as a 24 full factorial using the high level interactions to determine the significance of the main effects. Design of the experiment and levels of the factors are shown in Tables 1 and 2. All of these moldings were prepared using one piece of 30-mil veil mat to obtain a smooth surface. The molding mixtures were prepared with Selectron 5003L, a general purpose molding resin, and were agitated for 30 minutes at 1,500 rpm. One set of panels was molded with 1% pigment paste and a second set was molded with 5%, both based on the

Table I. The Color Changes in Panels Containing 1% Pigment Paste

	Mold Temperature 235° F.		Mold Temperature 265° F.	
	Cure Time 2 minutes	Cure Time 4 minutes	Cure Time 2 minutes	Cure Time 4 minutes
20% Surfex MM				
1% Cadox BTP	2.8	3.0	2.8	2.5
2% Cadox BTP	3.3	3.2	2.8	2.3
35% Surfex MM				
1% Cadox BTP	2.1	1.2	1.0	1.7
2% Cadox BTP	1.1	0.2	1.7	1.3

resin content of the mix. Color differences between these panels and the standard at each pigment level were then measured as previously described. The results of these measurements are shown in Tables 1 and 2.

Five additional sets of moldings, comprising the second series, were prepared each varying in other specific factors. The results of these color difference measurements and the factors involved are shown in Table 3.

Results

The data shown in Tables 1 and 2 were analyzed statistically using the Yates Method with error variance

Table 2. The Color Changes in Panels Containing 5% Pigment Paste

	Mold Temperature 235° F.		Mold Temperature 265° F.	
	Cure Time 2 minutes	Cure Time 4 minutes	Cure Time 2 minutes	Cure Time 4 minutes
20% Surfex MM				
1% Cadox BTP	1.3	1.5	1.4	1.3
2% Cadox BTP	1.3	1.7	1.4	1.4
35% Surfex MM				
1% Cadox BTP	0.4	0.6	0.3	0.8
2% Cadox BTP	0.7	0.6	0.5	0.6

Table 3. The Color Changes of Panels Molded in the Second Series

Factor Varied	@ 1% Pigment	@ 5% Pigment
15 mil veil mat in place of 30 mil	2.8	2.0
Molding mix agitated for 10 minutes instead of 30	3.7	1.8
Molding mix agitated at 250 rpm. instead of 1,500	3.3	1.7
20% ASP-400 in place of Surfex MM	26.6	14.0
35% ASP-400 in place of Surfex MM	29.8	18.1

Table 4. Analysis of Variance of Data Obtained From 1% Pigment Paste Moldings

Source of Variation		Degrees of Freedom	Mean Square
Mold Temperature	A	1	0.040
Cure Time	B	1	0.303
Catalyst Concentration	C	1	0.090
Filler Concentration	D*	1	9.610
Interaction	AB	1	0.090
	AC	1	0.122
	BC	1	0.160
	AD	1	0.563
	BD	1	0.040
	CD	1	0.303
Error (high level interactions)		5	0.275
Mean square required to indicate significance at 1% level, based on F test.			4.483

* Factors achieving significance.

Table 5. Analysis of Variance of Data Obtained From 5% Pigment Paste Moldings

Source of Variation		Degrees of Freedom	Mean Square
Mold Temperature	A	1	0.010
Cure Time	B	1	0.090
Catalyst Concentration	C	1	0.023
Filler Concentration	D*	1	2.880
Interaction	AB	1	0.023
	AC	1	0.010
	BC	1	0.010
	AD	1	0.003
	BD	1	0.010
	CD	1	0
Error (high level interactions)		5	0.031
Mean square required to indicate significance at 1% level, based on F test.			0.505

* Factors achieving significance.

being determined by the three and four factor interactions. Results of the data analysis at the 1% pigment paste level, which are shown in Table 4, indicated that variation in filler content produced a highly significant change in the color of the molding. None of the other variables or interactions of any two of the variables achieved a level of significance or affected the color. Results of the data analysis at the 5% pigment paste concentration, which are shown in Table 5 lead to the same conclusions as those obtained at the 1% level. It is significant, however, that the error variation and the $\Delta\Sigma$ values themselves were considerably lower at the 5% pigment paste level than they were at the 1% concentration. This would indicate that the 5% pigment paste level should give much better hiding and could reduce the effect of variations in the filler concentration.

The use of 15-mil veil mat instead of 30-mil produced significant visual changes in the color at both pigment levels (Table 3). In fact, the variation in pigment concentration would not seem to be important with this variable.

The large changes in panel color caused by a difference in mixing speed and time would indicate that variations of these two factors could create noticeable changes in the color of a molded part. Although an increase in the pigment paste concentration reduced the effects of these variables, they were not eliminated. It would appear then, that these two variables must be controlled to obtain uniform color.

The most obvious and expected color change was obtained when a china clay (ASP-400) was substituted for the calcium carbonate filler (Surfex). This would certainly indicate the necessity of matching the original color paste with the filler used in the molding.

Conclusions

The following conclusions were drawn from the data obtained:

The color of moldings can be visually changed by variations in the filler content of the molding mix.

Changes in the weight of veil mat may affect the color of the molded part.

(Continued on page 54)

Consultant's column Adhesives—part II

DR. S. S. STIVALA*

Q-4. Can you suggest a number of adhesives for bonding electric strain gages onto plastics? We have used Duco Cement, but found the measured strain to be in error for a number of thermoplastic specimens.

A-4. In 1958, I conducted (along with Mr. H. Sigler) a preliminary investigation** to determine whether or not adhesives suitable for bonding electric strain gages to plastics could be found. The possibility that differences between the modulus of elasticity of the specimen and that of the adhesive are important factors in the correct indication of strain was also investigated.

Unfortunately, none of the adhesives tested (nitrocellulose, rubber-base, polyvinyl chloride, polyester, and acrylic) were found satisfactory for bonding electric strain gages to the plastic specimens used in the investigation (polyvinyl chloride, polystyrene, and polymethyl methacrylate). The accuracy of electric strain gages for measuring strain of plastics under tension was determined by comparing the strain rate obtained from it to that observed with mechanical gages (extensometers).

The investigation led to the following conclusions:

1. SR-4 gages bonded to thermoplastic tensile specimens give elongation results which are appreciably lower than results obtained by use of a gage.

2. No definite conclusion could be drawn as to whether a correlation exists between the modulus of elasticity (E) of the adhesive and that of the adherends. In some cases, however, best results were obtained with high modulus sample in combination with high modulus adhesive.

Accurate strain data are obtained from SR-4 gages bonded to metal specimens with Duco Cement. There are two possible reasons why the adhesive SR-4 gage combination performs satisfactorily on metals but not on plastics. Since all plastic materials used were thermoplastic, the possibility existed of a chemical attack by the adhesive on the base material due to solvents or monomers contained in the adhesive. They would degrade that part of the specimen directly under the gage and would, if it occurred, be more serious in the case of specimens with small cross-sectional areas.

Secondly, with most medium- and low-modulus plastics, the rigidity of the gage itself is an important factor. If the shear modulus of the specimen material is sufficiently low, local deformation and flow will take place directly under the gage. Both of these effects will cause the SR-4 gage to record lower than a mechanical extensometer measuring the same length of smple. Neither of these effects occur in metal specimens.

No study of bonding SR-4 gages to thermoset materials was made; therefore, no conclusions can be drawn as to their suitability for use with such materials as glass-reinforced laminates. However, with some thermoset materials, Duco Cement gives highly satisfactory results.

For your specific application, perhaps the manufacturer of the strain gages can recommend an adhesive for the type of plastic material that you intend to investigate.

Q-5. How can plastics hope to compete successfully with metals and other materials in structural applications?

A-5. During the past two months I have received a number of questions pertaining to plastics whose properties will permit their use in structural applications. Many of the solutions to these problems are in the area of material selection. There are a number of plastics with improved mechanical properties which have permitted their use in structural applications traditionally restricted to metals and other structural materials. The most striking example of these successful structural applications is the use of unidirectional glass-epoxy laminates with specific tensile properties in excess of 1,000,000. Unfortunately, these improved properties are coupled with much lower moduli of elasticity than the metals.

Preliminary design and stress analysis would discourage many structural applications for plastics. However, the comparatively low modulus of elasticity of plastics does not present an impossible obstacle to structural applications but demands ingenious designing on the part of the engineer. This effort is fruitful, since plastics do offer a combination of unique thermal, chemical, electrical, and fabrication properties not available in any other class of materials.

Structural efficiency is, in the main, a function of

(Continued on page 54)

* Ass't. Professor, Stevens Institute of Technology, Dept. of Chemistry & Chemical Engrg., Hoboken, N.J.
* Plastics Engineering Consultant, S & S Engineering Associates, 280 Midland Ave., Saddle Brook, N. J.

** Sigler, H. and Stivala, S., "Adhesives for Attaching Electrical Strain Gages to Plastics," Picatinny Arsenal Tech. Note No. 21, (Oct. 1958).

ERRATUM

Corrected version of Table I in the Eastman article, "New Weathering Stabilizer For PVC," which appeared on page 47 in August.

Table 1. Compositions of Poly(vinyl chloride)

	Composition, Parts by Weight															
	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R
Geon 101	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Dioctyl phthalate	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Dibutyltin dilaurate		4														
Dibutyltin maleate			1													
Stabilizer S-3#			0.5													
Calcium stearate			0.3													
Carnauba wax			1													
2,2'-Dihydroxy-4,4'-dimethoxybenzophenone				4												
HPT (hexamethylphosphoric triamide)					2.5	2	2	2	2		2	2	2	2		
Sodium carbonate						2										
Staflex OY*							2			2						1
Ferro 900**							2			2						
Dibutyltin diacetate								2								
Flomax 25##									2							
Stabilizer 17-M#											2	1	1	1		
Epon 812***												1				
Diepoxide AG-13E###													1			
Stabilizer 201*****														1		
Ferro 1820**															2	
Triphenyl phosphite															1	
2,2'-Dihydroxy-4-methoxybenzophenone															0.2	
Paraplex G-62###																3
Mark PL****																1
2-Hydroxy-4-methoxybenzophenone																2

Made by Advance Solvents and Chemical Corp., New Brunswick, N. J. Stabilizer S-3 is a polymeric tin stabilizer; Stabilizer 17-M is an organotin-sulfur compound.
* Fatty acid salts from Deecy Products Co., Cambridge, Mass.
** Made by Ferro Chemical Corp., Bedford, O. Ferro 900 is an epoxy compound; Ferro 1820 is a barium-cadmium laurate.
Made by National Lead Co., New York, N. Y.
*** An epoxy compound made by Shell Chemical Corp., New York, N. Y.
Made by Rohm & Haas Co., Philadelphia, Pa. Paraplex G-62 is an epoxidized oil.
**** An organozinc compound from Argus Chemical Corp., Brooklyn, N. Y.
***** An epoxy compound from Union Carbide Corp.

The effect of molding conditions on the color of reinforced plastics moldings

(Cont'd. from page 52)

The use of a high (5%) concentration of pigment paste will reduce the visual significance of many of the critical variables.

A variation in catalyst content, mold time, or temperature should not affect the color of the molding.

Changes or poor control of the techniques used to mix the molding formulations can greatly affect the color of the moldings.

Changing the type of filler used in the molding mixture will greatly change the color of the molding.

Acknowledgment

The author wishes to thank Miss Ruth Johnston of Pittsburgh Plate Glass Company for her guidance in the color selection and the determination of the color data.

—THE END

Consultant's column

(Cont'd. from page 53)

the "stiffness factor" EI, where E is the modulus of elasticity and I is the moment of inertia of the cross section of the design. The first factor is a property of the material while the latter is a geometric or design parameter. The product designer cannot control the material property but he can and must utilize his ingenuity and experience in geometric design to make the plastic structural application successful. This technique is not new, but the comparatively low moduli of plastics make greater demands on the designer if these plastics are to be used successfully.

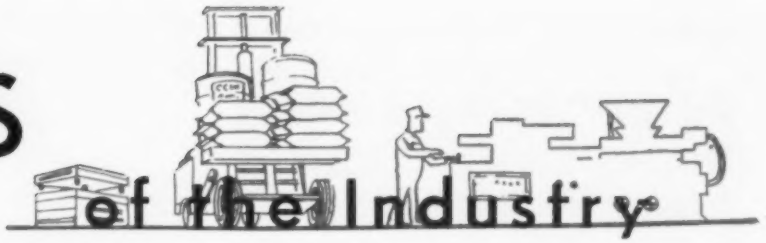
Shape or inertial (I) mechanisms such as ribs, sandwich panels, I-beam, T-beam, and the arch have been and should continue to be used in plastic design to improve the stiffness factor. A great deal of R & D work is being conducted to evaluate exotic structural shapes, such as hyperbolic paraboloids, which should increase the number of potential structural applications for plastics. It is obvious that designers will reap great rewards if their design incorporates the most efficient geometric shape with materials which have the highest specific strength properties—plastics.

The second approach to successful plastic structural applications is a "marriage" of plastics and non-plastics to provide a structural system which possesses the desired properties of each composite. The non-plastic component in these systems can provide increased modulus of elasticity and other desirable properties while not forcing the designer to pay too great a penalty in increased weight.

Plastics have and will continue to find their place in structural applications.

—THE END

NEWS of the Industry



agents, distributors & agreements

Reichhold Chemicals, Inc., has been licensed by Wacker Chemie, Munich, Germany, to produce vinyl acetate monomer.

Perkin-Elmer Corp., Norwalk, Conn., has arranged a leasing plan with Horton Equipment Leasing Division, Cambridge, Mass., whereby instrument users may lease P-E items for three years. Payments are monthly, and users may renew leases or purchase at a small percentage of original cost.

National Automatic Tool Co., Inc., Richmond, Ind., has appointed Acme Machinery & Mfg. Co., Inc., Worcester, Mass., as its New England distributor for the Natco line of plastics injection molding machines.

F. J. Stokes Corp. has named Hainge Co., Inc., Houston, Tex., manufacturer's representative for its line in the Southwest.

E. I. du Pont de Nemours & Co., Inc., has appointed Central Chemical Corp. its distributor for polyethylene film in Maryland, Pennsylvania, Ohio, Virginia, and Delaware.

Teleflex, Inc., North Wales, Pa., has appointed two western representatives: R. J. deRacat & Co. of San Francisco for the Southwest and Ron Marston Co. for Idaho, Oregon, and Washington.

United States Rubber Co. has named Brass & Copper Supply Co., Inc., Baltimore, Md., its distributor for plastics products of the mechanical goods division in the Maryland, Washington, and Virginia areas.

erratum

In August, we reported that George A. Shroyer was district sales manager for Hooker Chemical's Durez Plastics office in Dayton. This was incorrect. The district sales manager is D. J. Crain. We do not know how this happened, and hope this straightens out any confusion.

Perin Co., Inc., San Francisco, is now distributor for Tubar Materials handling equipment produced by Uhrden, Inc., with territories in northern California and Nevada.

Metalweld, Inc.'s protective coatings division has been selected Kabe-O-Rap distributor by Metal Cladding, Inc., North Tonawanda, N. Y., makers of reinforced plastic tanks for the chemical and allied industries. Metalweld's franchise includes New Jersey, Delaware, Maryland, and eastern Pennsylvania.

Sterling, Inc., Milwaukee, has appointed Application Engineering Corp., Franklin Park, Ill., its representative for Sterlco temperature control units in the Chicago area.

Whitlock Associates, Inc., Oak Park, Mich., named the following representatives: D. A. Olson Co., Seattle, Wash.; Application Engineering, Bensonville, Ill., Millholland-Conrad, Inc., Indianapolis; Tri-State Equipment Co., Inc., St. Louis; and John R. Davis & Co., Chamblee, Ga.

Tommy Tucker Plastics, Dallas, has been named distributor for Campco sheet and film in the Texas area.

Seiberling Rubber Co., plastics division, has appointed two sales representatives: Thomas W. Harber, Dallas, for Texas and Oklahoma; and Northeastern Industrial Sales Corp., Essex, Conn., for the New England states.

Adamson United Co., Akron, O., has become sole agent for the manufacture, sale, and service of the Shaw Internal Mixer in the United States. The unit will be sold under the name Adamson-Shaw Intermix.

Marblette Corp.'s Maraweld process has been approved by the New York City Board of Standards and Appeals for repairing fuel oil storage tanks. Industrionics Co., has been franchised to warehouse Maraweld materials in New York City and service tank repair organizations in the metropolitan area and New England.

general/specific

Powertron Ultrasonics Corp., Garden City, N. Y., offers an ultrasonic cleaner with an integral feedback transducer, which automatically adjusts phase and frequency for all conditions.

Union Carbide Plastics Co. has been field testing phenoxy compounds for the past six months. It has been decided to withdraw these materials due to prior patent applications. The firm is still testing these types of thermoplastic resins, and should have several new phenoxy materials available for field testing in the near future.

The Second Bachner Award competition for outstanding plastics applications is now open (closing date, March 10, 1961). The award, as before, consists of a trophy and $1,000 in cash. Information and entry blanks can be obtained by writing W. T. Cruse, The Society of the Plastics Industry, 250 Park Ave., New York, N.Y.

PLASTICS TECHNOLOGY
EXPLORING FABRICATION TECHNIQUES

By L. J. ZUKOR, *ENGINEERING EDITOR*

Vinyl Records

• Over 60% of the people in the United States own some type of record player.

• Over 600,000 juke boxes are operating in this country.

• Over 100 manufacturers are presently producing more than 300,000,000 records a year, 80% of which are manufactured by the "Big Six" (RCA, Columbia, Capitol, Decca, MGM, and Mercury).

New techniques, new speeds, high-fi, stereo — all milestones in a sixty-year old industry—are today helping to produce and sell more records and record playing equipment than ever before. Having met the challenge of both radio and television, the record making industry has been able to thrive profitably as a result of several new manufacturing processes.

In making a record, performances are first taped. This offers advantages over discs, since tapes can be edited and spliced. Many records consist of two or more separate tape recordings electronically combined to make a master tape which can be monitored by the operator during play-back. He controls the signal level as it modulates (vibrates) the cutting stylus of a disc recorder. Sizes of master discs and reproductions have been partially standardized at 7, 10, 12, and 16 inches, while speeds have tended to standardize at 78, 45, and 33⅓ rpm. Several turntable manufacturers are presently including 16⅔ rpm. speeds on their equipment, in anticipation that this speed will become a standard when ultra long playing records become available.

Lacquer-coated aluminum has completely displaced the older waxes for making master discs commercially. Improvements in cutting techniques and the heated stylus have greatly improved the surface finish of the groove cut into the cellulose lacquer discs. Extremely fine surface finish (0.5-1.0 micro inch) is vital throughout all operations.

The public has become accustomed to extremely low noise levels. From these, the audio engineer sets up a "signal to noise ratio." Expressed in decibels, this ratio is a measurement of an arbitrary standard signal compared to the noise generated by the surface of a record.

After being engraved, the lacquer disc is coated with an electrical conducting surface suitable for electroplating either by chemical precipitation of silver (silver reduction) or vacuum metallizing (cathode sputtering). The latter method is thought to be an important contribution to the reduced surface noise of the best records.

A metal negative replica is prepared by electroforming, reproducing the grooves and surface finish in extreme detail. This die, called a negative master, is sometimes used to make selected pressings or, if the run is small, it becomes the stamper. Ordinarily, the negative master is used to make an electroformed nickle-faced mold called a "mother" from which many stampers can be made.

Preparing stampers involves special treatment to facilitate stripping them from the cathode masters. The most frequently used method is a chemical treat-

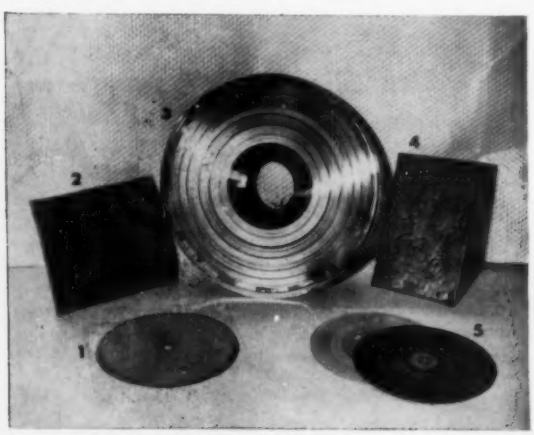


Photo courtesy: Cary Chemicals Inc.

(1) Sinterfused biscuit prepared by partial sintering of powdered unfilled resin.
(2) Calendered biscuit prepared by cutting unfilled resin sheet.
(3) Pure nickle, 12 inch, 33-1/3 rpm., stamper containing six selections.
(4) Filled biscuit containing almost 50% filler.
(5) Seven inch, 45 and 33-1/3 rpm. records. The darker disc was made from a sinterfused biscuit and the lighter disc was made from boomer compound.

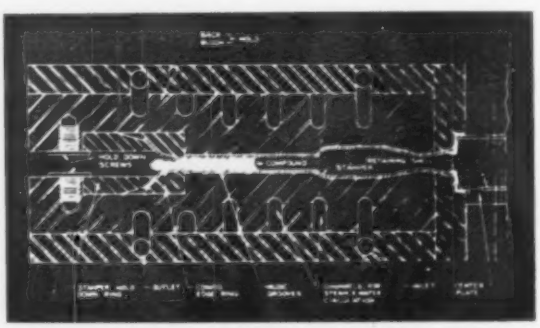


Photo courtesy: RCA Inc.

Sectioned diagram of record mold showing stamper assembly.

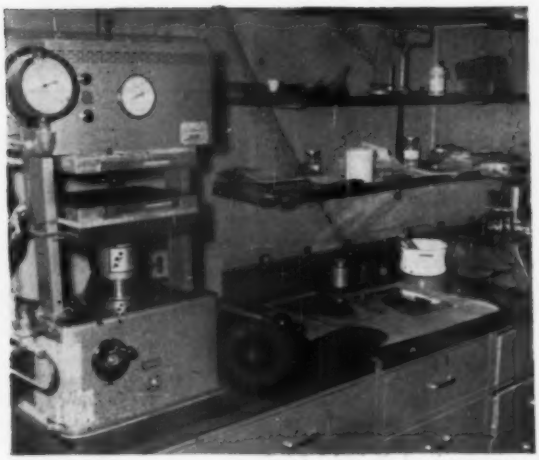


Photo courtesy: The Borden Chemical Co.

Abrasive particle test set-up.

Resin sample is pressed between ferrotype plates.—Surface scratches are revealed when abrasive particles are present in sample.

Photo courtesy: Components Corp.

Hydraulically operated record press.

Containing one set of heating and another of cooling platens. Also shown is a book type mold suitable for molding sinterfused biscuits.

ment whereby an insoluble compound is formed on the cathode surface. A recent technique uses a metal negative master to produce thermoplastic "mothers" by a careful pressing operation, similar to the pressing of commercial records. These are vacuum metallized with gold or silver, and are used to make electroformed stampers.

Molding begins after the stampers are intimately mounted to mold halves which are equipped with passages for steam and cooling water. Compression molding is the predominant method used for producing records. Injection molding has also been tried, but with relatively poor results.

An important factor which made possible the microgroove record, is the vinyl record compound. Record makers chose unplasticized vinyl and vinyl copolymers because these could be processed on existing equipment. These resins, hard yet ductile, can support heavy compressive loads. Further, its high surface finish and nonabrasive qualities result in a very low surface noise.

Recently, on a trip to the Borden Chemical plant in Leominster, Mass., I had an opportunity to check some of the latest trends in record making with Richard Lee, Product Manager for record resins. During our discussion, I learned that Borden Chemical, Cary Chemical, Union Carbide Plastics, and other resin manufacturers have introduced antistatic resins which can be compounded by record manufacturers to make records totally free of static electricity. These antistatic chemicals can best be described as cationic surfactants. One, a quaternary ammonium salt, is American Cyanamid's Catanac SN. This material is reportedly compatible with vinyl copolymers and their (special) stabilizer systems, and is effective at low relative humidity. Anti-static materials tend to accelerate the decomposition of a resin compound. Because of this, shorter processing periods are recommended when milling, extruding, or molding at temperatures exceeding 300° F.

I learned too, that more pellets than powders are presently being sold to the record industry. New nondusting powdered resins are being tried in vertical plasticators ("Boomers") and, if successful, will replace the more costly pellets. Although calendered biscuits are still being prepared, boomer compound is the trend in most large operations.

The general acceptance of 33⅓ rpm. for LP's in both monaural and stereophonic recordings has created a trend toward an increase in the number of lines (grooves) to the inch. Records are commercially available today with 250-350 lines per inch. Jerry Minter, President of Components Corp., Denville, N. J., reports that he has successfully experimented with 4,000 lines per inch. His equipment has proved that 700 lines per inch on present vinyl record compounds is a commercial possibility.

—THE END

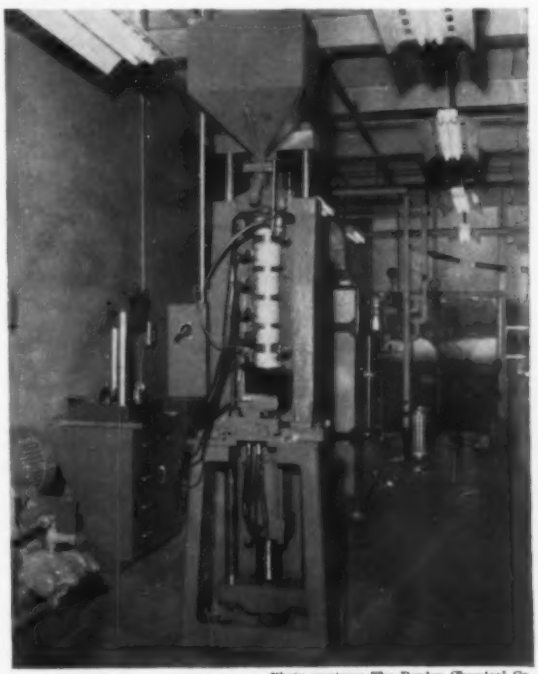


Photo courtesy: The Borden Chemical Co.

Garden State vertical plasticator (boomer).

Names in the News

James L. Musgrove

James L. Musgrove, formerly with Foxboro Co.'s sales organization, has been appointed southwestern regional sales manager for Instron Engineering Corp. He will set up offices in Houston, Texas.

Mandell S. Ziegler, who had been associated for the past ten years with the research and sales division of the polychemicals department, E. I. du Pont de Nemours & Co., has joined Russell Reinforced Plastics Corp. as director of research and development. Dr. Ziegler played an important role in the technical and commercial development of Lucite acrylic sirups, for which Russell was the first reinforced plastics molder to develop a fabricating technique.

Robert E. Ward has left General Aniline and Film Corp., where he was a production supervisor, to become plant manager of Carwin Co.'s North Haven, Conn., plant.

Joseph W. Selden

Joseph W. Selden has been elected division vice president for the chemical division, Minnesota Mining & Manufacturing Co. Mr. Selden, who has been with 3M since 1948, has been general manager of the chemical division since 1959, and was assistant general manager for the preceding four years.

Don B. Pettry has been designated sales manager at Flexible Products Co. He had been employed by Firestone Plastics Co. as a chemist and sales engineer.

Harry E. Roche, manager of the Port Arthur, Tex., plant of Koppers plastics division, retired on May 31 after 26 years of service. He is succeeded by **Alfred M. Miller, Jr.,** formerly assistant manager at that location.

Van W. Bearinger has been named director of research for Minneapolis-Honeywell Regulator Co. At the same time, **John N. Dempsey** and **Edward E. Rexer** were named assistant research directors. Dr. Bearinger, who has been associate research director since 1956, succeeds **Dr. Finn J. Larsen,** elected a corporate vice president in charge of research a year ago.

S. Richard Stout, sales manager for Glascote Products, subsidiary of A. O. Smith Corp., since 1956, has been elected vice president of sales. He joined Smith in 1950, and has been sales manager for the past four years.

Thomas H. Eaton

Thomas H. Eaton has been appointed vice president and general manager of Johns-Manville Corp., fiber glass division, Toledo. He succeeds **Francis H. May, Jr.,** now assistant vice president for finance of Johns-Manville Corp. Mr. Eaton, who has been assistant general manager since February, will be in charge of operations at six plants.

Harry J. Pratt has been named general manager, plastics division, Amos-Thompson Corp. He comes from General Electric Co., where he worked for 19 years.

Carl E. Druggs, a production engineer, has been promoted to the position of works manager of the Compton, Calif., plant of Borden Chemical Co. He will be responsible for all phases of local production engineering.

Wyman L. Taylor has been promoted to the position of assistant to the vice president-sales, industrial chemicals division, Stauffer Chemical Co. He most recently was western sales manager for the division.

Paul E. Geiser has been promoted by Continental Oil Co. from manager of the detergents division to general manager of petrochemical manufacturing. Assistant general manager of petrochemical manufacturing will be **K. R. Gerhart. J. E. Waples** will succeed Mr. Gerhart as superintendent of the Gretna, La. petrochemical plant.

Dr. Turner Alfrey, Jr.

Turner Alfrey, Jr., has been named a research scientist by Dow Chemical Co. in order to devote full time to scientific and consulting work. He is also a special consultant to the plastics department. Dr. Alfrey's former duties as director of the Polymer Research Laboratory have been assumed by **William R. Nummy.** Dr. Nummy, who will carry the title of assistant director, has been assistant director of the Physical Research Laboratory since 1956.

As a result of the death of **Eli Sandman,** president and general manager, Eli Sandman Co. has announced the following personnel changes. **Dora L. Sandman** has assumed overall general management, succeeding her husband as president and treasurer. **Harold N. Cotton** has been appointed sales manager in addition to continuing his duties as assistant to the president. **Jean L. Lewis,** technical director, has been named plant superintendent.

Frank M. Norton, formerly executive vice president of Plastics and Coal Chemicals division, Allied Chemical Corp., has been named president of the division. Mr. Norton, who joined the company in 1932 as a chemical engineer with Semet-Solvay division, had been executive vice president since 1959.

Benjamin J. Skowronski has been named manager of midwestern sales by National Polychemicals, Inc. Before this appointment he had been a technical service representative for Neville Chemical Co.

John I. Rudge

John I. Rudge has assumed the position of executive vice president in charge of marketing at Carlon Products Corp. He comes to headquarters in Aurora, O., after having served since 1958 as vice president in charge of Carlon's southeastern district, Asheville, N. C.

New Materials For more information check Readers' Service Card (p. 89)

Reinforced Polyester Premix

Fibercore 1200 is a glass fiber-reinforced polyester compound for compression and transfer molding. According to Plumb Chemical Corp., it is characterized by high impact strength, good chemical resistance, and low specific gravity. Preforming is not required.

Bulk factor is approximately 3:1. Curing time for a ⅛-inch section at 300° F is 60 seconds. Minimum shelf life below 85° F. is 60 days from date of shipment. Although properties obtained in parts molded from Fibercore 1200 will vary with design, molding conditions, and molding methods, the following is offered as a guide.

Specific gravity	1.80
Mold shrinkage, in/in.	0.002
Water absorption, %, 24 hrs. @ 23° C.	0.35
Impact strength, Izod, ft. lbs./in. notch	8–12
Compressive strength, psi.	15,000–20,000
Flexural strength, psi.	14,000–19,000
Flexural modulus, psi.	$1.2–1.6 \times 10^6$

Readers' Service Item 1

Anti-Static Compound

Clarkson Laboratories, Inc., has made available a material which protects plastic phonograph records from developing static and picking up dust. Clarco antistatic compound, a soft, 100% active material, is added to the batch before molding, one pound per 100 pounds of mix. According to the company, records will remain remarkably free from surface noise through hundreds of playings.

Readers' Service Item 2

Three Polystyrenes

Dow Chemical Co. has added a heat resistant, general purpose polystyrene and two high impact polystyrenes to its line of Styron resins. General purpose Styron 690 can be injection molded or extruded for such applications as radio cabinets, brush bristles, packaging containers, and television lenses. For injection molding, cylinder temperatures 475-600° F., and mold surface temperatures 150-180° F., are recommended for quality parts.

Tensile strength of a sample ⅛ inch thick by ½ inch deep is 7,900 psi. Per cent of elongation is 2.3; impact strength, 0.47 foot pounds per inch of notch; deflection temperature under 264 psi. load, 210° F.

Of the two high impact resins, Styron 475B is an extrusion resin recommended for thermoforming, and 475C for molding, especially in thin section parts or where long flow areas are encountered. Both can be used for containers and refrigerator and small appliance parts.

The two materials have similar properties. Styron 475C is easier to mold and has slightly less heat resistance and impact strength than 475B.

Readers' Service Item 3

Safer MEK Peroxide

The development of a safer formulation of methyl ethyl ketone peroxide has been announced by U. S. Peroxygen Corp. Designated Hi-Point 180, the material has a flash point as high as 220° F., but in no case below 180° F.

Used primarily as a catalyst for vinyl, acrylic, and polyester resins, the water white liquid has a specific gravity of 1.13.

The safety features of Hi-Point 180 have been incorporated in the company's Quickset high reactivity MEK peroxide.

Readers' Service Item 4

Oriented Fibrous Resins

Vinyl and styrene polymers in the form of highly oriented fibers are available in developmental quantities from Union Carbide Plastics Co. The vinyl resin is designated VXKA-6112 and the styrene resin SXKA-0121. Of irregular shape with diameters ranging from two to 200 microns, the fibers are of different lengths up to 3/16 inch. They appear to have application in the preparation of specialty papers, in pulp and paper molding, and in laminates. There also are possibilities for their use as binders for non-woven textiles which can be produced on paper making equipment.

Paper prepared with fibrous resins is reported to have improved dimensional stability, abrasion resistance (with vinyl), wet tensile strength, surface smoothness, and grease resistance. Water absorption is reduced proportionately to the amount of fibrous resin added. Further, resin-treated papers are heat-sealable. Burst and tensile strengths and folding endurance decrease as resin is added. Calendering improves these properties, but not sufficiently to equal the controls.

Paper containing fibrous resin can be laminated under heat and pressure as it issues from the paper machine. Creped papers can be compression molded to form three-dimensionally curved structures.

Readers' Service Item 5

Light Colored Phenolic Resin

National Polychemicals, Inc., has announced the development of Poly-Phen S-218, a phenolic resin for use in light colored compounds based on natural rubber and styrene-butadiene copolymers. According to the company, the resin, as compared with others on the market, will impart substantially lighter color and better color stability while providing good reinforcement. It is currently on the market in uncatalyzed flakes and powder and as a catalyzed powder for use in compounding composition soles, top lifts, and miscellaneous mechanical goods.

A two-step, thermosetting resin, this modified phenol-formaldehyde has a specific gravity of approximately 1.20. Bulk density is 20-25 pounds per cubic foot. Softening point is 80-90° C.; stroke cure at 150° C., 90-110 seconds.

Readers' Service Item 6

White Lead PVC Stabilizers

Basic lead carbonate powder and pastes for stabilization of PVC compounds are now offered by South American Minerals and Merchandise Corp. Samincorp white lead stabilizers are made in several grades, differing mainly in particle size and shape and chemical composition. The two principal grades are medium stain and high stain. When medium and high stain grades are incorporated at similar concentrations in similar compounds, the latter provides longer heat stability, less gassing, greater opacity, and greater viscosity.

Both white stabilizers have a specific gravity of 6.74. Lead carbonate content of medium stain is 74-45%; of high stain, 66-67%. Each has less than 0.3% content of moisture and volatiles. Medium stain consists mainly of hexagonal plates; high stain is entirely comprised of hexagonal plates. Median particle diameter is six microns. Range of particle size is narrower in high stain; oil absorption is greater.

Readers' Service Item 7

IN BLOW-MOLDING

Hi-fax® Sets the Standard Other Materials Strive to Match

TODAY

TAILORMADE FOR TOUGH JOBS

These nesting Hi-fax bottles carry the water supply for a housetrailer; they were custom-blown to fit available space in trailer interior.

Hi-fax, high-density polyethylene, was the pioneer plastic in thin-wall, blown containers. Hi-fax set the standard . . . was the first material approved by both producers and users of plastic containers for light-duty liquid detergents. While other materials seek to match the Hi-fax standard, Hi-fax remains universally in demand in this first major market for blow-molded high-density polyethylene products.

The same physical and processing properties which enabled Hi-fax to pioneer the breakthrough in detergent bottles have proved equally useful in household chemical, drug and cosmetic containers, and in the development and production of industrial packages of increasingly larger size and scope.

As blow-molding horizons broaden, Hi-fax will continue to lead the way . . . in product testing, market development, and continuous research designed to improve the properties and performance of today's finest blow-molding material.

BIG FAVORITE WITH BIG BRAND NAMES

Hi-fax blown containers are now used by all of the major manufacturers of light-duty liquid detergents.

FOUR VARIATIONS ON A THEME

Avon uses the same Hi-fax container to package both liquid and dry products in its new line of children's cosmetics.

HI-FAX LEADS THE WAY

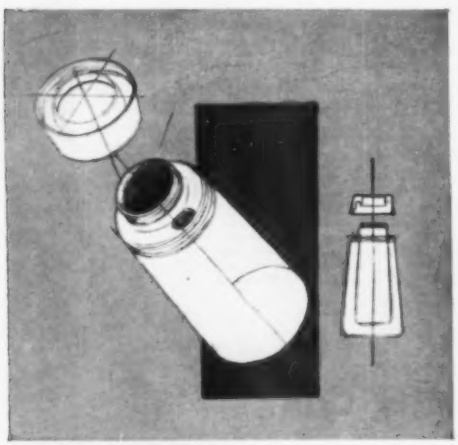
The larger the part—the greater the need for Hi-fax

TOMORROW

Growing faster than any other sector of the plastics industry, blow-molding now reaches out into many new markets: industrial packaging, sporting goods, toys, furniture, lighting, and automotive and marine parts. Parts grow larger as improved equipment and processing techniques keep pace with new demands. And still leading the way is Hi-fax, for the larger the part, the greater the need for Hi-fax in terms of superior physical properties and ease of processing.

Hi-fax leads the way, too, in new market developments. Hercules blow-molding experts are ready to help you with design and product planning, in order that you may achieve maximum economies in material and production costs.

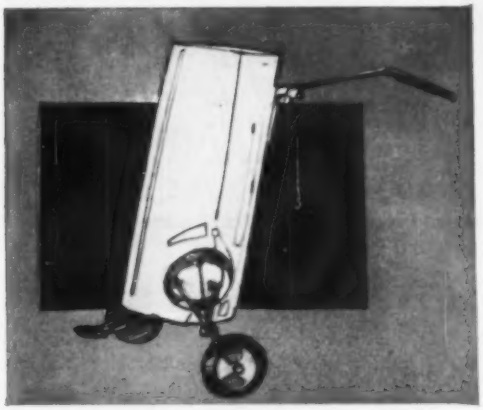
Here's a preview of some of the brand new product ideas now possible with Hi-fax and blow-molding:



INDUSTRIAL PACKAGING:

Double-wall bottle solves the packaging problem which arises when two separate ingredients in a product must be shipped separately for mixing immediately prior to use. Blow-molded with Hi-fax, this combination bottle would have the all-important stress-crack resistance so necessary when corrosive products are involved.

ORIGINAL DESIGNS BY SUNDBERG-FERAR, DETROIT, MICH.



SPORTING GOODS:

This ingenious design for a golf cart combines bag and wheeled-carrier in a single, compact, lightweight unit which can be readily blow-molded with Hi-fax.

Wheels (and tires, if desired) could be blown parts, too. Complete unit would be highly functional, less tiring to use, weather-resistant, and significantly lower in cost.

TOYS:

Tough, but handsome, too, blow-molded Hi-fax has just what it takes for the design of such modern-styled outdoor toys as this. Both body and wheels could be blown with Hi-fax, resulting in a unit that would be less than half the weight of a metal counterpart, with a finish that would not dent, chip off, rust or corrode.

HERCULES

HERCULES POWDER COMPANY
INCORPORATED
Hercules Tower, 910 Market Street, Wilmington 99, Delaware

THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

CP60-15

Keep your
PRODUCTS
younger
longer

HARCHEM SEBACATE PLASTICIZERS

Keep your vinyl products from showing their age in use and they'll keep building good will and good volume for you.
Harchem Sebacate Plasticizers give vinyls built-in resistance to heat, cold, water or physical abuse.
Harchem offers four Harflex Sebacic Acid Esters. Check the list below for the one best suited to fight aging, weathering and wear for you.

will do it!

Plasticizer	Specific Gravity 25°/25°C ±.002	Viscosity 25°C, cps	Compatible With	Outstanding Characteristics
Dibenzyl Sebacate	1.055	21-22	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers	Excellent Solvation, Very Low Volatility, Permanence, Good Electricals, Low Temp. Flexibility
Dibutyl Sebacate	0.935	7.9	Vinyl Resins, Cellulose Acetobutyrate, Synthetic Rubbers, Rubber Hydrochloride, Polymethyl Methacrylate	Low Temp. Flexibility, Excellent Aging Qualities, Non-Toxic
Dimethyl Sebacate	0.986*	3.54 @30°C	Vinyl Resins, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate, Acrylic Resins	High Solvency and Efficiency, Wide Compatibility, Concentrated Source of Sebacyl Radical
Dioctyl Sebacate	0.913	17.4	Polyvinyl Chloride and Copolymers, Polyvinyl Butyral, Synthetic Rubbers, Cellulose Nitrate, Cellulose Acetobutyrate	Excellent Low Temp. Flexibility, Low Volatility, Excellent Soapy Water Resistance, Good Electricals

*30°/20°C

WRITE FOR SAMPLES AND BULLETIN

THE KEY TO HARCHEM® BETTER PLASTICS

HARCHEM DIVISION

WALLACE & TIERNAN, INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
IN CANADA: W C HARDESTY CO OF CANADA, LTD . TORONTO

Equipment Cleaning Compound

A cleaning compound reported to remove any thermoplastic material from extrusion and injection machines has been developed by Allied Chemical Corp.'s petrochemical division. With injection machines, A-C Cleaning Compound is placed in the hopper and fed to cylinders in the usual manner. Temperatures should approximate the most recent molding conditions to allow residual polymer to be melted and removed easily. The cleaning compound has a low melt index, enabling it to remain in a semi-stiff state in the molten stage. This stiffness performs the scrubbing to remove polymers and foreign matter from the equipment.

The amount of cleaner required depends on the size of the cylinder and the degree of contamination. Restrictions such as dispersion plates or pineapple mixers should be removed from the nozzle. For effective cleaning, it is advisable to vary the plunger speed.

When used on extruders, dies and screen packs should be removed. Barrel profile temperature should be about 425-450° F., or slightly higher if contaminants have a higher melting point.

Readers' Service Item 8

Honeycomb Core Materials

Hexcel Products Inc. has developed a series of fiberglass-reinforced, heat resistant, honeycomb core materials for use in aircraft and missiles. Tradenamed HRP, the core consists of woven glass cloth impregnated with a high temperature phenolic resin and separately applied high temperature phenolic dip coats. The series includes six core materials ranging in density from two pounds per cubic foot to 15 pounds per cubic foot in cell sizes of ⅜ inch and $\frac{3}{16}$ inch.

Readers' Service Item 9

Plasticizer Intermediate

Abco Chemical Co. has made available 1,2,3,4 tetracarboxybutane, a grayish polyfunctional acid melting at 187-191° C. It is a highly reactive acid useful for the preparation of esters having potential applications as plasticizers and high temperature lubricants. Potential applications in coatings include the preparation of alkyds, polyesters, and polyurethanes. The acid or its anhydride may possibly be important as an epoxy curing agent.

TCB is soluble in water and most polar solvents, and insoluble in hydrocarbons.

Readers' Service Item 10

Available

WET OR DRY

The ***WORKHORSE CATALYST*** *for* ***POLYMERIZING SYNTHETIC RESINS***

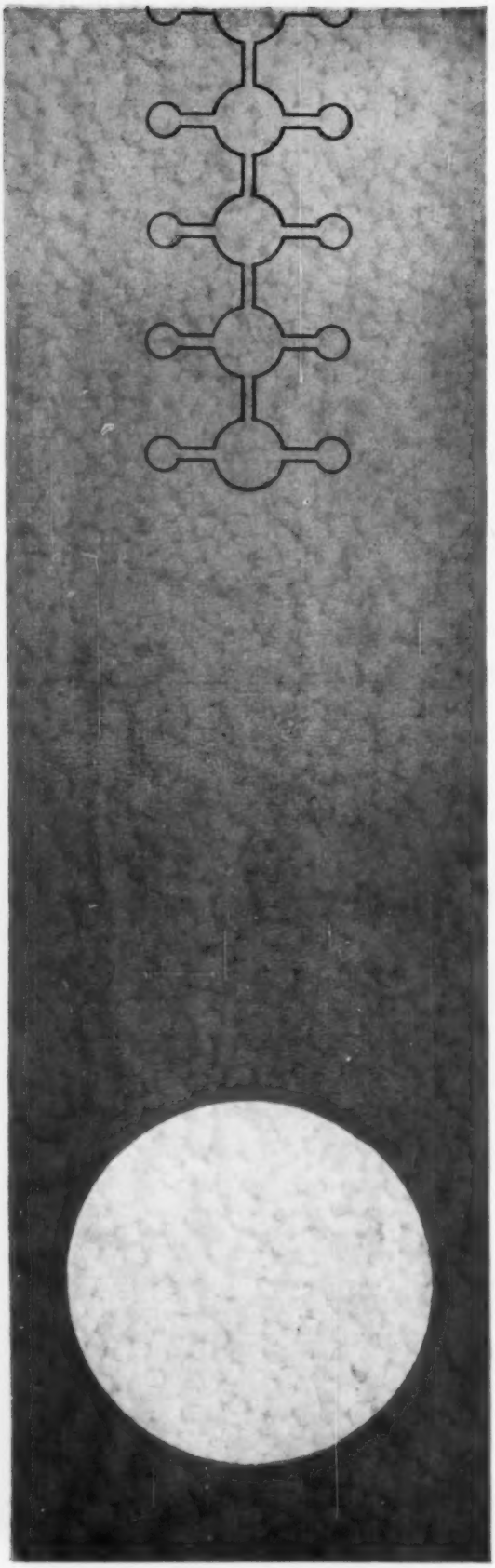
Lucidol Benzoyl Peroxide

In dry form, Lucidol Benzoyl Peroxide has long been the quality standard of the industry. It is available, for those who prefer it, in wet form (20-25% water). The peroxide net weight per package is the same. The applications are identical — polymerization of vinyl acetate, vinyl chloride, vinylidene chloride, methylmethacrylate, styrene and unsaturated polyesters — and for copolymerizations of the same monomers.

Write for Data Sheet or Consult Chemical Materials Catalog Page 199 for further data.

LUCIDOL DIVISION

WALLACE & TIERNAN INCORPORATED
1740 MILITARY ROAD
BUFFALO 5, NEW YORK



Du Pont introduces the first of many new

THE NEW

High-density resins with these important features:

- shorter cycles
- less warpage
- low molded-in stresses
- greater toughness
- new melt-flow behavior

The ALATHON 7000 resins are high-density polyethylenes made by employing the most modern technology. Control of the melt-flow properties has been successfully achieved, so that instead of the familiar combination of viscous and elastic flow found in other high-density polyethylenes, these resins flow almost entirely in a truly viscous manner. As a result, these new ALATHON resins offer lower molded-in stresses than ever before available. There is little or no warping of large-area or thin-walled moldings—a common difficulty with other types of high-density polyethylene resins. In addition, low molded-in stress provides greater toughness . . . and permits appreciably shorter molding cycles in many instances. The ALATHON 7000 resins are introduced in a range of melt indices from 0.5 to 15.0.

A product of basic polyolefin research, ALATHON 7000 is the

ALATHON® polyethylene resins

"ALATHON" 7000 RESINS

first series of many new polyethylene resins to be offered by Du Pont to meet the needs of processors and end users. Newly expanded manufacturing facilities will enable Du Pont to provide the greatest range of polyethylene resins—in high, medium and low densities—available anywhere in the plastics industry. A high degree of flexibility in manufacture will allow the production of resins with controlled properties—both solid state and processing. Du Pont can now offer the largest-size blends in the industry to insure uniformity from lot to lot.

The new resins are available in a full range of packages: bags, pillar-pacs, collapsible neoprene balloons (10,000 lbs.) and hopper cars. For more information write to: Dept. FF-10, Room 2507A, Nemours Building, E. I. du Pont de Nemours & Co. (Inc.), Wilmington 98, Delaware.

POLYCHEMICALS DEPARTMENT

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*

Fibercore MOLDING COMPOUNDS

ARE
- POLYESTER MOLDING MATERIALS reinforced with natural and synthetic fibers FIBERGLASS—NYLON—SISAL
- Easy to handle—Ready to use
- Available in Three Standard Grades
  - *Chemical Resistant*
  - *Electrical*
  - *Flame Resistant—Electrical*

CAN BE
- Specially formulated to meet specific application requirements

PROVIDE
- High impact strength
- Low specific gravity
- Excellent chemical resistance
- Superior electrical properties
- Dimensional stability
- Smooth surface finish

PERMIT
- Complex part design
- Use of metal inserts
- Unrestricted use of colors

AVAILABLE ON REQUEST

- Literature and price information
- Free samples for initial evaluation
- Assistance in selecting the Fibercore Molding Compound best suited for your application
- Help in tooling-up and starting production

Write, Wire or Telephone

PLUMB.

CHEMICAL CORPORATION

4837 JAMES STREET · PHILADELPHIA 37, PA.

3 WAY SAVINGS WITH D-M-E STANDARD MOLD BASES

1 FASTER SERVICE

Delivery from local stock means you get standard Mold Bases, components and mold-maker's supplies when you need them—direct from D-M-E's fully-stocked local branches!

2 ADDED QUALITY

Exclusive features at standard prices! First-quality steel; surfaces ground flat and square; patented tubular dowels; one-piece ejector housing; stop-pins welded to ejector bar; sizes to 23¾" x 35½".

3 GREATER ECONOMY

Interchangeability lets you replace *any* component without special fitting or reworking! Choose from over 7,000 cataloged Mold Base combinations.

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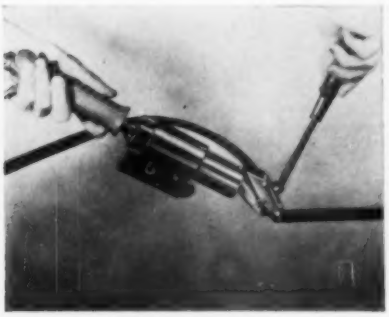
New Equipment

For more information check Readers' Service Card (p. 89)



Allen-Universal welding gun.

Thermoplastic Welder

The Allen-Universal welding gun can be used for any thermoplastic weldable by the hot gas method. Available from Esto Manufacturing Co., Inc., the gun weighs only 12 ounces. Four standard welding tips, as well as a special roller tip, are stocked. A control valve in the gun handle regulates the air stream volume and prevents burning at weld-starts due to over-supply of hot air. An easily attachable light facilitates welding in dark interiors.

Readers' Service Item 21

Extruder Screws

Wayne Machine & Die Co., will supply standard replacement or special application extruder screws quickly and economically. This service has already been performed with users of all makes of extruders. Screws with constant and varipitch of alloy steel are also flame hardened and chrome plated to round out the required essentials for the user.

Wayne extruder screw.

Readers' Service Item 22

Pump Tank for Water Chillers

Applications Engineering Corp. has developed two pump tank units to increase the efficiency of its Multitem industrial water chillers. The units are reported to insure a continuous and uniform flow of water to a process regardless of the number of process units operating at any given time.

The 2500 series is engineered to meet specifications requiring absolute pressure and flow control. Measuring 30 by 20 by 36 inches, the machines are shipped completely assembled and ready to install by connecting water, power, and drainage. Model 2500 is ceiling mounted for space economy, with the selector switch centrally located for access.

Model 3000 pump tank set is designed for use in process cooling and for established cooling tower systems. The units, 48 or 60 or 72 by 30 by 48 inches, can be mounted on the floor or on a stand, and can be furnished in single or double tank systems with single or multiple pumps. Upon connection with power, water make up source, process supply, and return, Model 3000 is ready for use. An automatic flow control valve is optional.

Readers' Service Item 23

1000-Watt Ultrasonic Cleaner

Powertron Ultrasonics Corp. has announced the availability of a 1000-watt ultrasonic cleaner with self tuning. The generator, Autosonic Model PA-10001, provides an average output of one kw., with a four kw. peak. Operated by a single switch, it is 17 inches long, 17½ inches wide, and 18 inches high. Multiple units may be combined in modular installations to give up to ten kw. operation.

Tanks of 8- and 32-gallon capacities in the PT-10001 series, as well as tanks from smaller systems, can be driven by the generator. Special equipment can be produced to specifications.

Readers' Service Item 24

Bulk Materials Handler

Working with specially designed bulk material containers, Silent Hoist & Crane Co.'s Lift-O-Krane is reported to speed work, spare men, and slash costs involved in bulk materials handling. The cab-mounted lift, available in eight capacities from 8-15 tons, will transfer materials from truck or railroad to the ground or other storage place. Sealdbin collapsible containers, products of U. S. Rubber Co., allow bulk materials to be stored out of doors regardless of weather.

From a seat in the cab, a single operator has access to controls for lifting and tilting, traveling in forward and reverse, and brakes. The system is recommended for handling of such materials as polyethylene, PVC, and carbon black.

Collapsible container system for bulk material transport.

Readers' Service Item 25

Injection Molding Machinery

A series of 12/16-ounce plastic injection molding machines is reported by Reed-Prentice Division, Package Machinery Co., to feature high clamping capacity, fast cycling, large die space, and long stroke.

The machines are equipped with a monitor-type safety circuit. The front safety door has double limit switches and a hydraulic lock. If any part of the safety circuit fails, the machine will open and stop.

Plasticizing capacity of the standard straight-bore heating cylinders is 150 pounds per hour. An optional heater plasticizes 180 pounds per hour. The heating chambers will handle all thermoplastics. Specifications of the three models in the series are:

	350OTCL	350OTC	450OTC
Clamp force, tons	372	356	450
Clamp stroke, inches	8½–20½	7½–14½	6–22–5⅝
Mold platens, inches	32½ x 32½	32½ x 32½	40 x 40
Tie bar diameter, inches	4	4	5
Space between tie bars, inches	20½ x 20½	20½ x 20½	26 x 26
Distance between platens, max., inches	44¾	36½	47 – 1⅛
Length of dry cycle, seconds	7¾	6-3/3	
Cycles per hour	465	535	
Dimensions			
Length, inches	229	229	
Width, inches	66	66	
Height, inches	86	86	

Readers' Service Item 26

KOHNSTAMM PIGMENTS IN EVERY SHADE FOR EVERY TYPE MATERIAL

Our colors are specially treated to eliminate dusting and aid in dispersability

Whatever your need – basic chemical pigments, cadmium colors or specially formulated and treated colorant blends...we manufacture them all.

Our laboratory is available for consultation on any color problem.

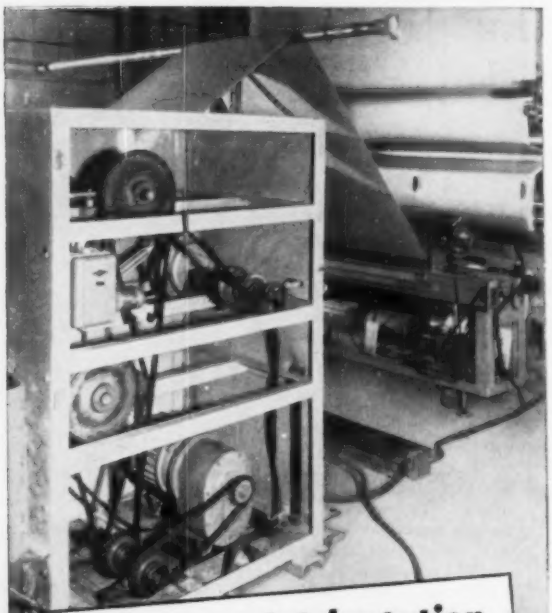
H. KOHNSTAMM & CO. INC.

Experts in Color Technology for More Than a Century

161 Avenue of the Americas, New York 13
11-13 E. Illinois Street, Chicago 11
2632 E. 54 Street, Huntington Park, California

BRANCHES IN OTHER PRINCIPAL CITIES OF THE U. S. A. AND THROUGHOUT THE WORLD

HOBBS-CHP WEB WINDING



An Unusual Adaptation at CROWN RUBBER COMPANY

The Foam Division of Crown Rubber Company at Fremont, Ohio utilizes Hobbs CHP Web Winding Equipment in an unusual way. The winding stand is mounted on wheels so that it may be moved from one location to another to rewind a wide variety of web weights and widths—from cheese cloth to carpeting up to 9 feet wide—after coating with latex foam rubber. This mobility is feasible because of the light weight and compact design of the winder.

In spite of the diversity of webs handled, Crown reports that proper tension is maintained in all cases. Quality of rewound material is exceptionally high because tension is controlled automatically. The motor increases torque as the roll builds up and slows down in direct proportion. Thus constant HP, which is the equivalent of constant tension, is maintained.

Hobbs has the answer for practically any web winding problem. Its various types of winders are described in "Principles and Practices of Modern Winding". Send for your copy. No obligations.

WEB WINDERS • SLITTERS
SHEARS (Hand & Power) • DIE
PRESSES • AUTOMATIC CUTTERS

HOBBS EST. 1902 *Manufacturing Company*
781 Salisbury St., Worcester 5, Mass.

Representatives in Irvington, N. J., Chicago, Cleveland, Louisville, Greenville, S. C., Los Angeles, Toronto and other Principal Cities

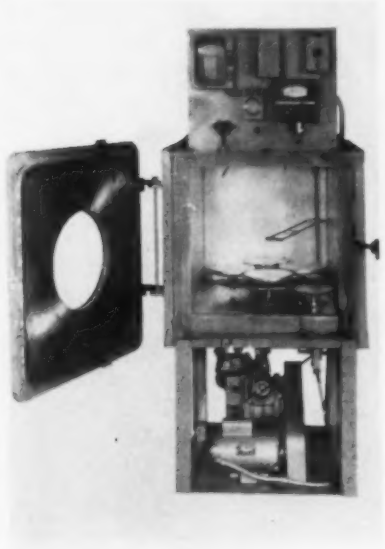
102-9

Plastic Casting Oven

A casting oven designed to accommodate four or more casting molds at one time has been announced by Metallizing Co. of America. The unit is reported to eliminate air and moisture from castings.

Molds are placed on individual tables, which can be rotated from the outside for filling. At temperatures up to 500° F. and vacuums of 29 inches or more, the casting material can be catalyzed, heated, deaerated, poured, and finish baked.

The oven is fully jacketed for efficient oil transfer heating. Oil is electrically heated. Oven has porthole-type front window, heat and vacuum gages, and electric control switch. Controls, gages, and oven entry are in front. The unit illustrated has a capacity of eight cubic feet, but the oven can be ordered to any desired specifications.



Four-table casting oven.

Readers' Service Item 27

18/24 Ounce Injection Molder

Lombard Governor Corp. has added an $18/_{24}$ ounce injection molding machine to its line of injection molding equipment. The machine features large platens, daylight opening of 50 inches, and locking pressure of 450 tons. Plunger speeds are over 400 inches per minute.

Standard equipment includes weigh feeding, dual pressure injection controls, plunger advance and stuffing controls, plunger speed control, linkage speed control, hydraulic positioning of injection and linkage units, and other features.

Readers' Service Item 28

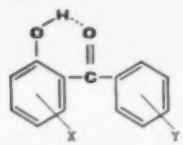
TENITE DEVELOPMENT LABORATORY DOINGS AND FINDINGS

GREENHOUSES, SUNSHINE, AND STABILIZERS

Have you ever potted a plant or seeded a small patch of ground, and experienced the thrill of watching it blossom out? To raise the more exotic flowers, to extend the growing season, or simply to find more room when the grower's better half won't put up with any more plants in the house, the true enthusiast builds himself a greenhouse.

Now that polyethylene is available in weather-resistant formulations, horticulturists can put up a simple wooden frame and cover it with inexpensive, but surprisingly durable, polyethylene film. As might be expected, polyethlene-covered greenhouses are also becoming popular with the commercial grower.

It took some effort, of course, to develop a polyethylene formulation that could withstand the destructive ultraviolet rays in sunlight and yet permit the visible ones necessary for healthy plant growth to shine through. Eastman plastics laboratories found that non-pigmenting compounds having the general configuration shown here provided polyethylene with the necessary protection when dispersed in the material.



The success of these compounds in stabilizing the plastic lies not so much in their ability to absorb ultraviolet radiation as in their ability to dispose of it in easy stages, at no time releasing a harmful amount of energy to surroundings.

Although a number of compounds having the chelate structure shown above make satisfactory stabilizers, it was found by measuring the nuclear magnetic resonance spectra of these compounds (with a nuclear magnetic spectrometer—what else?) that the X and Y groups which strengthened the electronic density within the carbonyl group and decreased it within the hydroxy group improved the ability of the compound to rid itself harmlessly of the absorbed ultraviolet energy. The compound that had the configuration which proved to protect polyethylene best is now incorporated in certain formulations of Tenite polyethylene to make them unusually resistant to sunlight and weathering.

In addition to weather-resistant Tenite Polyethylene, Eastman also offers highly weather-resistant formulations of Tenite Polypropylene and Tenite Butyrate. For further information, drop us a line.

NEW SIGNS FOR OUR TIMES

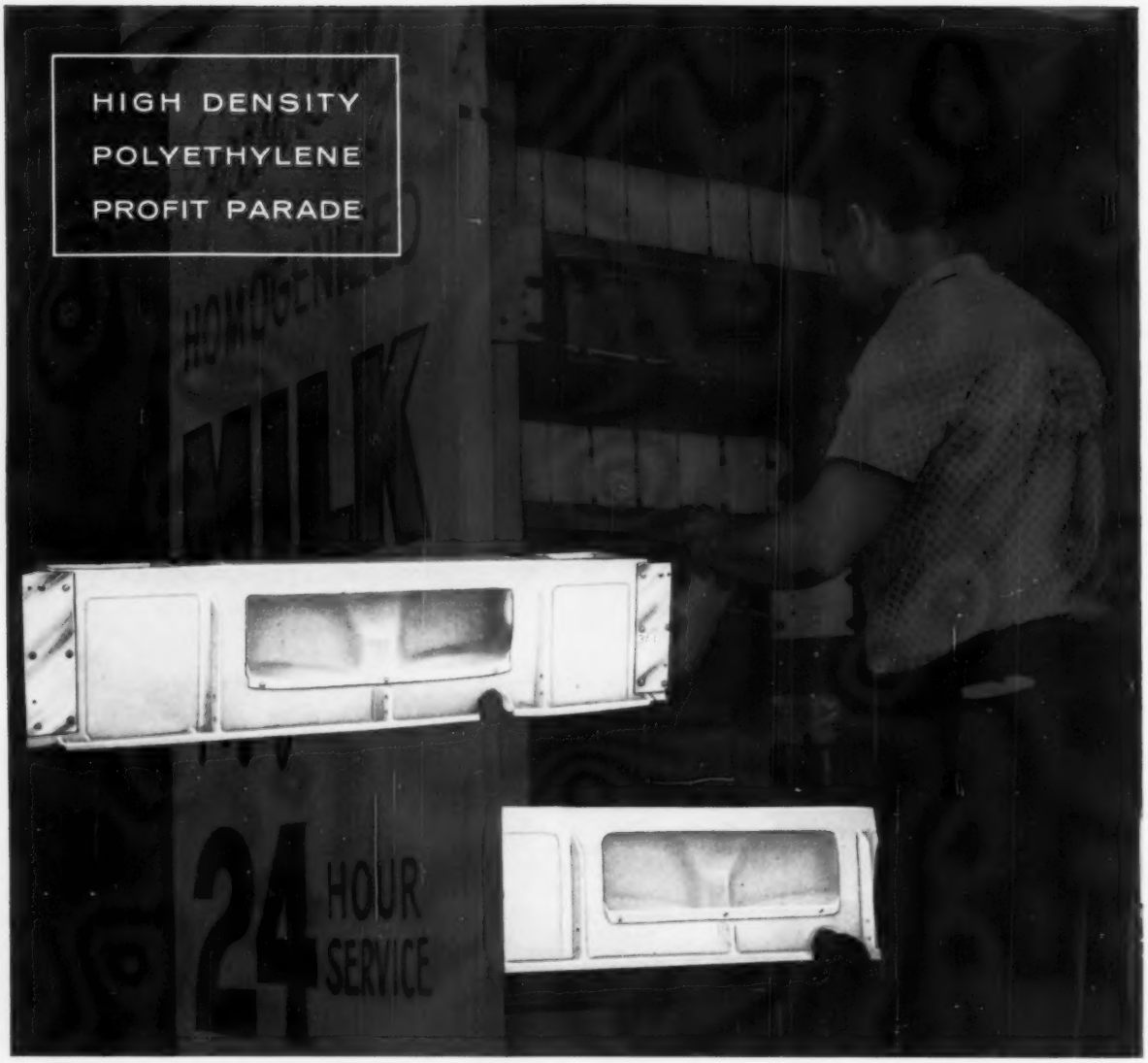
If you've been traveling over the country on your vacation and have observed weathered and rusty signs, you'll be happy to learn that the day is at hand when signs can be lastingly bright and legible. No longer need sign lettering wear dim and become unreadable. In fact, producing a sign no longer requires paint. The thing that makes all this possible is a new two-layered, weather-resistant butyrate plastic sheet which we have developed ready for commercialization by custom extruders.

This duplex sheet is produced by a simple butyrate-to-butyrate sheet-coating operation worked out by the Eastman plastics laboratories. Although it has two layers of contrasting color, the sheet is a single, uniform thickness, with pigmentation change at its interface.

Shown here is a sign made from duplex sheet. First, the sheet was "drape-formed" over a mold which raised the lettering on the sign face. Then, surfaces of the raised letters were wet-sanded to remove their upper layer of plastic. This permitted the contrasting color of the plastic below to show through. Since the upper layer of a typical 100-mil sheet is only 10 mils, sanding takes just about 5 seconds. Water sprayed on during the sanding operation keeps down the temperature of the plastic and prevents it from gumming the abrasive.

We market only the resin and do not ourselves commercially extrude or fabricate sheet. But if you have some questions about duplex sheet, we will try to answer them. Write to Eastman Chemical Products, Inc., Plastics Division, Kingsport, Tennessee.

TENITE®
plastics by Eastman



Part Goes to Grace Plastic for Greater Durability

Automatic Milk Service, Inc. improved the performance of its coin operated milk vending machines through a change in design and material for one key part. The part is a chute through which milk cartons are dispensed. Produced the new way, it rarely requires repairs or maintenance.

The chute is subjected to rugged treatment every time the machine is operated (a carton of milk is released from above and hits the chute with considerable impact), and every time the machine is filled (the serviceman uses the chute as a platform to hold his milk case). Many different materials were tested for the part. Grace's high density polyethylene was chosen as the material that could withstand such abuse over a long period. The chute was redesigned for efficient vacuum forming with Grex sheet by Highland Products, Inc.

Chutes made from this Grace plastic stand up so well they rarely require attention. Even in cold weather, when other plastic materials lose their strength, these Grex chutes will not crack or break on impact.

For the vending machine company the use of Grex means longer chute life and lower maintenance costs. Perhaps you can reduce costs, too, by taking advantage of Grex for your products. The best way to find out is by calling in the experts. Grace has the production, technical and marketing facilities to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

Large part designed with deep draws successfully vacuum formed from Grex sheet.

The experience of Highland Products, Inc. in redesigning and forming the chute for milk dispensing machines may give you some ideas on how to take maximum advantage of Grex for your *own* projects.

Simplification in design was the first step in production of the part. Originally it was a complicated assembly of nearly twenty pieces. The new design by Highland calls for only two large vacuum formed Grex pieces plus three flat Grex strips as stiffening members.

Deep draw required. In the interests of production efficiency and part performance, Highland's design calls for deep draws, straight walls and sharp corners. Such design requirements are difficult to satisfy in thermoforming many types of plastic sheet. The fact that satisfactory parts are being produced may be attributed to the thermoforming characteristics of high density polyethylene.

Slow cooling an advantage. High density polyethylene remains workable for a relatively long period. In this case, the Grex sheet is workable for 60 to 90 seconds after drawdown—sufficient time to obtain necessary detail on the sides of the pieces.

Want to know more about what can be accomplished by vacuum forming of Grex sheet? If you have an application in mind, give Grace Technical Service the opportunity to help you. We may not know all the answers, but we do have experience with high density polyethylene on our side—and are learning more every day.

Technical Service Department
W. R. Grace & Co., Clifton, New Jersey

Laboratory Mixing Machine

The Forster Rotomixer, distributed by Testing Machines, Inc., has been designed especially to mix sample batches of large bulk materials. For thorough compounding, the mixing chamber rotates in two changing planes simultaneously. The product container is made of thick, clear Perspex plastic, enabling the mix to be observed during the operation. It can be detached easily, thus allowing use of a number of containers.

Internally, the container is 12 inches long and 6½ inches in diameter. Since the normal mix will occupy approximately half this volume, mix capacity is approximately 200 cubic inches.

Laboratory Rotomixer.

Readers' Service Item 29

Ultrasonic Cleaning Transducer

Consistent maximum efficiency and optimum performance in ultrasonic cleaning are reportedly achieved through the use of Powertron Ultrasonics Corp.'s Autosonic feedback transducer, which automatically adjusts phase and frequency for all conditions. The transducer measures the amount of ultrasonic activity in the cleaning tanks, and corrects output to maintain the standing wave condition. Consequently, maximum cavitation is maintained automatically for all conditions.

The unit is piezoelectric, with an efficiency estimated at more than 90%. Cleaning systems range in capacity from 100—3,000 watts, with generator-tank combinations in several sizes from ¾ gallon to 75 gallons.

Readers' Service Item 30

Portable Test Instrument

All types of plastics can be tested for tensile, compression, transverse, and shear forces with the Dillon Model M tester. Manufactured by W. C. Dillon & Co., Inc., the unit operates by means of a calibrated pendulum, guaranteed within ½ of 1% of indicated reading.

On the single eight-inch dial are five ranges from 0-10 pounds to 0-300 pounds. Calibration is available in ounces, tenths of pounds, or kilos. Permanent stress-strain curves may be obtained by using an accessory rotating drum recording system.

Model M testers come with manual handwheel or motors. All are supplied with controlled temperature cabinets with working ranges from room temperature to 400° F.

Readers' Service Item 31

Injection Machine Equipment

Injection Molders Supply Co. has announced the availability of an automatic high heat circulator and a line of bolted type replacement heating cylinders. The cylinders, designed for vinyl molding or where easy dismantling for cleaning is necessary, can be adapted to any injection press. Many are carried in stock for immediate shipment.

The high heat circulator, for resins such as acetals, polycarbonates, and nylon, features an insulated double wall tank. One control knob regulates both heating and cooling. The thermostat regulates temperatures 50-400° F., with best control range 70-350° F. Cooling is from 350° F. to 50° F. above the cold water supply. Available for 220 volt 60 cycle 3 phase operation, the circulator comes equipped with a ¼ hp., 1,725 rpm motor, two thermostatically controlled heaters, casters, and large dial thermometer. It can be used on any injection machine.

Readers' Service Item 32

Cylindrical Band Heaters

Acromark Co. is supplying a small, bench unit for code marking plastic, metal, and fiber parts and products. Consisting of a base, a "U" frame with upright to carry pneumatic equipment, an interchangeable die holder, and a fixed product holder, the unit will mark items that require relatively unnoticeable identification after manufacture. The marker is approximately 6 inches wide, 12 inches high, and 10 inches deep.

Readers' Service Item 33

CIGARETTE FIRE DESTROYS BUS
Loss Set At $7,500 In Hackensack Blaze
Hackensack — An Inter-City bus parked at the company's Passaic Street terminal was destroyed last night in a raging fire caused by a lighted cigarette left on a seat of the vehicle.
A spokesman for the company said the $7,500 bus was a total loss.
Engine Company 5 of the Fairmount Station responded to an 8:24 P. M. call, and had the fire under control in 20 minutes.

Photo courtesy Bergen Evening Record, Hackensack, N. J.

Add flame-resistance to your plastics with CELANESE PHOSPHATE PLASTICIZERS

Celanese plasticizers do much more than impart fire-resistant characteristics:—they provide rapid solvation with most resins, assure permanence, are resistant to extraction by oils and water. Celanese gives you four different grades of tricresyl phosphate: low color, low specific gravity, general purpose, and electrical grades. Celanese chlorinated phosphate plasticizers are outstanding for flame retardance. They are often used as additives in thermosetting plastics for their fire-retardant properties alone. For information on Celanese phosphate plasticizers, write to: Celanese Chemical Company, a Division of Celanese Corporation of America, Dept. 564-J, 180 Madison Ave., N. Y. 16. Celanese® Lindol® Celluflex® Celluphos®

- **LINDOL:** Tricresyl phosphate. Low color.
- **CELLUFLEX 179A:** Tricresyl phosphate. Low specific gravity.
- **CELLUFLEX 179C:** Tricresyl phosphate. General purpose.
- **CELLUFLEX 179EG:** Tricresyl phosphate. Electrical grade.
- **CELLUFLEX 112:** Cresyl diphenyl phosphate. Improved low temperature performance.
- **CELLUFLEX TPP:** Triphenyl phosphate. For cellulose acetate.
- **CELLUPHOS 4:** Tributyl phosphate. For nitrile elastomers.
- **CELLUFLEX CEF:** Tris (beta-chloroethyl) phosphate. Exceptional flame resistance. Chlorinated.
- **CELLUFLEX FR-2:** Tris (dichloropropyl) phosphate. Exceptional flame resistance. High chlorine content.

Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pan Amcel Co., Inc., 180 Madison Ave., New York 16.

Celanese CHEMICALS

Plastics Applications

For more information check Readers' Service Card (p. 89)

Plastray pitcher and cap.

Polyethylene Pitcher

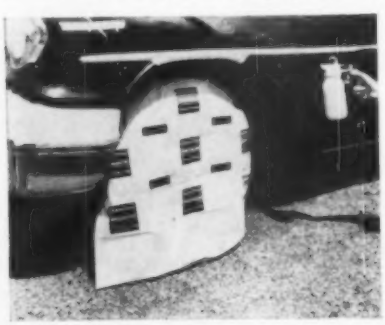
A combination two-quart shaker and pitcher is being made by Plastray Corp. from W. R. Grace's boilable Grex high density polyethylene. Designed to hold hot or cold beverages, the pitcher comes with a threaded, screw-on cover for shaking and refrigerator storage.

The pitcher has a slim handle for comfortable grip, and a no-drip pouring spout for clean serving. It comes in turquoise, yellow, and pink with matching lids, or natural with colored lids.

Readers' Service Item 41

Car Wheel Covers

Martin-Senour Paint Co. has designed polyethylene film covers to protect car wheels during spray painting. Fabricated by Central States Paper and Bag Co. of Union Carbide's Bakelite polyethylene, the covers can be reused many times.



Polyethylene film tire protectors.

Due to a special back fold, the covers can be draped over each wheel without bother of individual clamping, tying, or taping.

Since the covers are printed with the trademark of the paint company, they also serve to promote sales of automotive finishes. They have been distributed to paint shops throughout the country.

Readers' Service Item 42

Glass-Epoxy Laminate

Spauldite G11-820, a glass based epoxy laminate developed by Spaulding Fibre Co., Inc., is reported to maintain over 50% of its flexural strength at 150° C. temperatures without any loss of its high electrical and mechanical properties. Recommended for computer, missile, and aircraft components, the material is available in 40 by 48 inch sheets, copper clad or unclad strips, blocks, or custom fabricated parts. Thicknesses range from 1/32 to ½ inch.

Readers' Service Item 43

Control Panel Wireway

A four-inch high control panel wireway in 1-, 1½-, 2-, and 3-inch widths is being produced by E C P Corp. Since the top, bottom, and sides are independent, the four-inch sides may be purchased separately for substitution for three-inch sides in wireway already in stock. The wireway is claimed to save wire, duct material, and installation time.

Molded of flame resistant, grey vinyl, the wireway has deep slots in the sides to permit more efficient use of available space. They extend close to the top lip of the duct so that they can be cut for faster insertion of the wire. Sides may be purchased with cut slots if desired.

Readers' Service Item 44

Rocket Launcher Fairings

Rocket launcher fairings for McDonnell Aircraft Corp.'s supersonic F-101A interceptors are being produced in quantity by the reinforced plastics division of REF Manufacturing Corp. Mounted under the F-101's wing, the fairings direct air flow around the rocket launchers, preventing excess drag at supersonic speeds.

Rocket launcher fairings for supersonic interceptors.

Match-molded from several layers of polyester-preimpregnated fiberglass, the fairings are formed at high temperature and pressure, and then oven-cured. After cooling, they are machined to blueprint dimensions and sprayed with a coat of black, anti-static neoprene which makes them completely waterproof.

Produced under contract with Benrus Watch Co., the fairings are manufactured to close tolerances. The thickness of 0.060 inches is held to ±0.005, as are mounting holes drilled around the base. Dimensions are 11.69 by 4.546 by 3.60 inches, each having a tolerance of ±0.030 or less. The fairings weigh eight ounces.

Readers' Service Item 45

Polystyrene surf boards.

Fish-Shaped Surf Boards

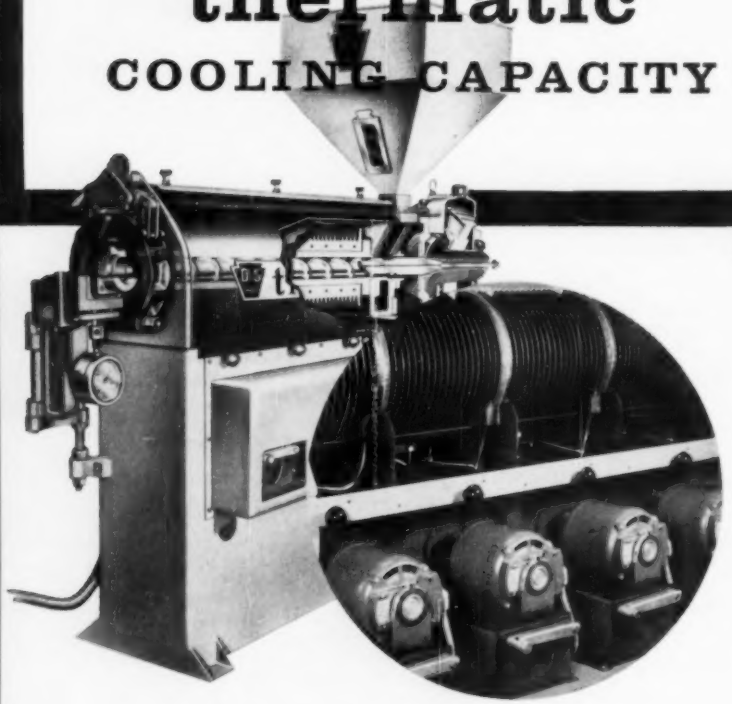
Surf boards molded of polystyrene in the shape of whales and sharks are available from Pycofoam Corp. Named the surf riders, the boards are buoyant enough to support the weight of an adult. The whale measures 32 by 12 by 2 inches, and he shark, 35 by 12 by 3½ inches.

Readers' Service Item 46

SOONER OR LATER

BLOW MOLDERS WILL NEED thermatic*

COOLING CAPACITY



*Patented

Suppose you run linear polyethylene of low melt indices from .2 to .4 . . .

D-S Thermatic cooling capacity permits lower stock temperature of the extruded tube for faster mold cycles.

On dry color blending–a competitive necessity–high screw speed for compounding is unlimited by temperature control problems due to the cooling capacity of the D-S Thermatic.

Don't lose time and money on special stock screws and slow production rates when what you really need is THERMATIC COOLING CAPACITY

D-S thermatic

DAVIS-STANDARD

Division of FRANKLIN RESEARCH AND DEVELOPMENT CORPORATION

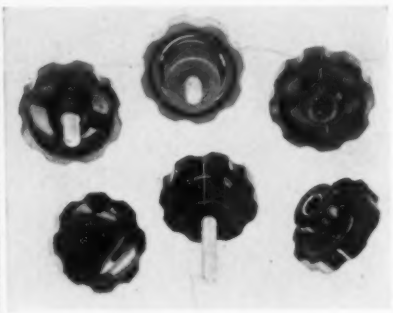
15 WATER STREET, MYSTIC, CONNECTICUT

NAME _____ TITLE _____

STREET _____ STATE _____

COMPANY _____

PRECISION EXTRUSION CONTROL IS OUR BUSINESS



Dimco-Gray fluted knobs.

Knobs and Handwheels

A fluted grip for heavy duty and high torque clamping devices, valves, regulators, etc., is the outstanding characteristic of a line of molded knobs and handwheels introduced by Dimco-Gray Co. Parts are produced from stock molds. For modifications to individualize stock parts, a slight tooling charge is added.

Both knobs and handwheels are 2⅜ inches O.D., available with plain cored holes, tapped brass inserts, and protruding studs. Knobs, with ½-inch longer hubs than handwheels, can also be obtained with reamed brass bushings and set screws for ¼- to ½-inch diameter shafts. While black phenolic is the standard material, parts may be purchased in many phenolic and urea colors and with such special characteristics as chemical and heat resistance, impact resistance, and low friction.

Readers' Service Item 47

Microphone Housing

The microphone of a transistorized portable dictation machine produced by Comptometer Corp. is housed in Cycolac ABS thermoplastic supplied by Marbon Chemical division, Borg-Warner Corp. This rigid material protects the unit from falls and blows. The protective end cap on the dictating machine itself is also molded of Cycolac.

Use of this material enabled engineers to keep the weight of the recorder down to 4½ pounds.

Comptometer Coronet dictation machine.

Readers' Service Item 48

HERE is your answer to mixing, production, and source problems:

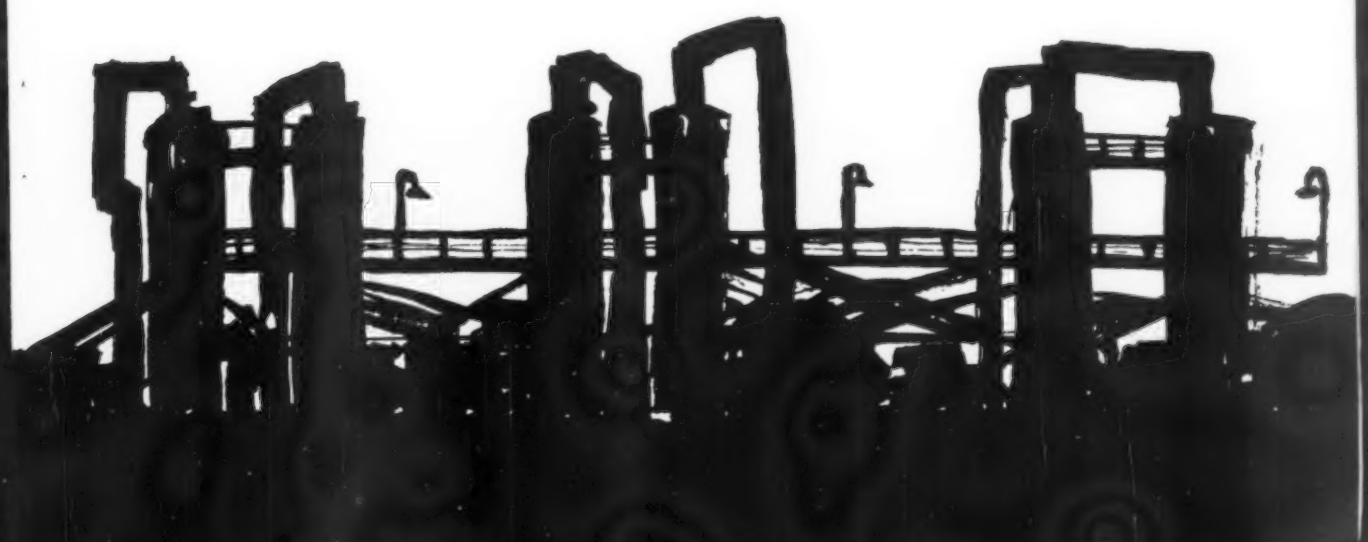
COMPOUNDING INGREDIENTS FOR RUBBER

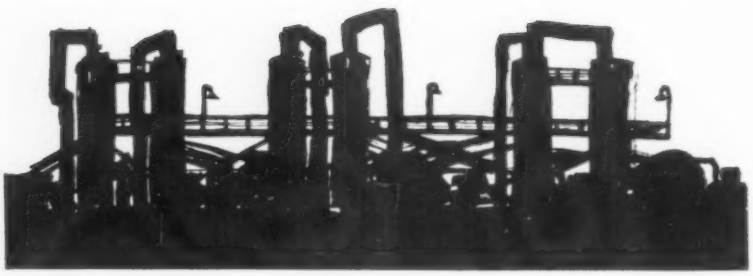
THIRD EDITION

Now going to press—the Third Edition of the only book of its kind ever offered the Rubber Industry.

It will have over 600 pages of editorial content, with authoritative descriptions for each type of material or ingredient. Names and addresses of all suppliers are included. A partial list of contents follows:

Part One —DRY RUBBER COMPOUNDING MATERIALS
1—VULCANIZING MATERIALS
2—PROTECTIVE MATERIALS
3—PROCESSING MATERIALS
4—FILLERS AND REINFORCING MATERIALS
5—COLORING MATERIALS
6—SURFACE MATERIALS
7—AUXILIARY MATERIALS





Part Two —LATEX COMPOUNDING INGREDIENTS
1—FUNCTIONAL GROUPS FOR LATEX ONLY
2—MATERIALS PREPARED FOR LATEX USE

Part Three—NATURAL AND SYNTHETIC RUBBERS, LATICES, AND RECLAIMS
1—NATURAL RUBBER
2—SYNTHETIC RUBBERS
3—RECLAIMED RUBBER
4—NATURAL RUBBER LATICES
5—SYNTHETIC RUBBER LATICES

Part Four —NAMES AND ADDRESSES OF SUPPLIERS

Under the above headings there are sixty different subheadings. This is a complete evaluation of materials and ingredients of interest to men in the Rubber Industry. Furthermore, it is an up-to-date study, containing the latest information available.

Cloth-bound, this new Edition of "Compounding Ingredients for Rubber" is sold for $15.00 a copy in the U.S.A.; $16.00 a copy elsewhere.

Since the big book is selling fast, your early response is urged. An on-approval order blank is below. May we hear from you?

FOR YOUR CONVENIENCE

RUBBER WORLD,
630 Third Avenue,
New York 17, N. Y.

Please send ..... copy(ies) of your new book "COMPOUNDING INGREDIENTS FOR RUBBER," @ $15.00 per copy in the U.S.A.; $16.00 prepaid elsewhere.

It is understood that we are privileged to return any or all copies ordered within ten days if we are not entirely satisfied.

Individual ..... Title .....

Company .....

Street ..... City ..... Zone ..... State .....

..... Check enclosed. ..... Send invoice. (U.S.A. orders only)

Implex housing for pool alarm.

Swimming Pool Alarm

The Transista pool alarm sets up a warning horn whenever anything over ten pounds falls into a pool where the device is in use. Marketed by Home Pool Equipment Corp., the alarm consists of a transistor circuit inside an Implex housing. Thus, hazards of charged wires in contact with the water are eliminated. A setting plunger and sensitivity screw are the only controls.

Placed in the water, the Transista will float until something or somebody falls into the pool. The resulting horn can be heard up to 500 feet away, and will continue until the alarm is reset.

Implex acrylic resin for the housing is supplied by Rohm and Haas.

Readers' Service Item 49

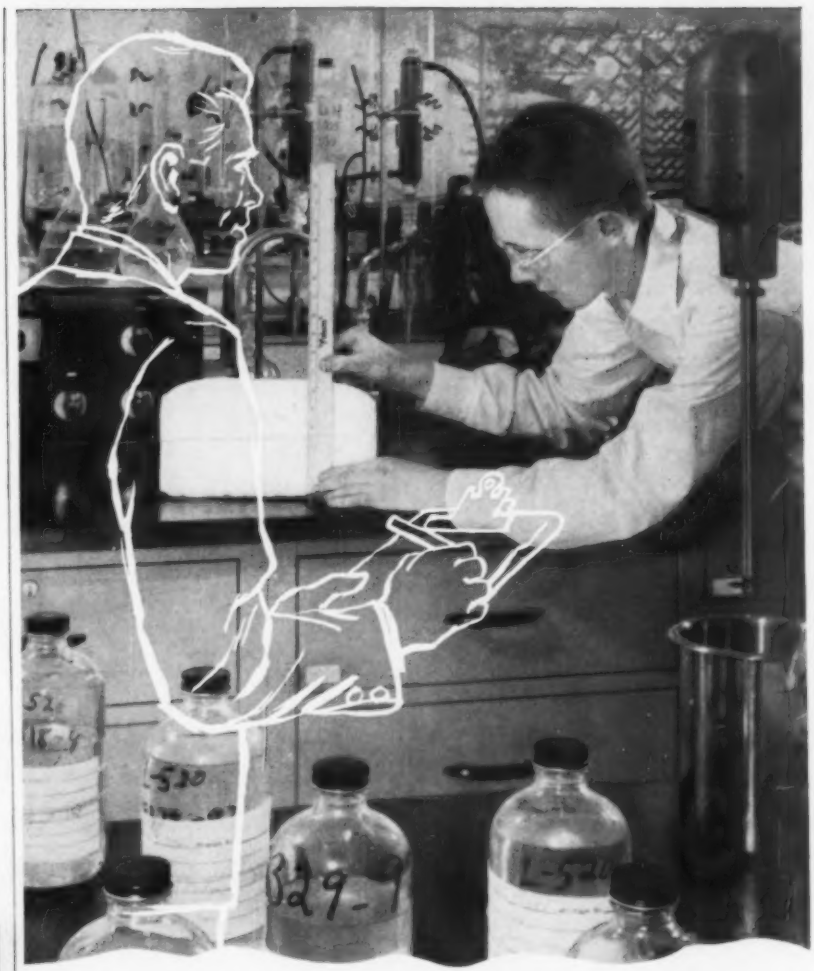
Micro slide mailing containers.

Mailing Package for Slides

Monrovia Plastics Co., Inc., has designed a mailing package for microscope slides. Up to four slides are inserted into grooves molded within the plastic cylinder and secured by a heavily-threaded screw cap. The caps fit so tightly that slides may be surrounded with preservative liquids without possibility of leakage.

Molded of Super Dylan polyethylene, a product of Koppers Co., Inc., the containers weigh one ounce and are 1¼ inch in diameter and 4⅛ inches long. The new containers eliminate the need for padding to protect the slides and for external wrappings.

Readers' Service Item 50



HOW THE SILICONES MAN KNOWS...

YOUR ONE-SHOT FOAM SURFACTANT IS ALWAYS UNIFORM

Every production batch of UNION CARBIDE L-520 Silicone Surfactant for one-shot polyether foams is thoroughly laboratory tested. This way, your Silicones Man can be sure it is *always uniform in the properties important for foam production.*

Tests are made on a standard one-shot foam formulation. The L-520 must meet minimum requirements for foam rise, settling at the height of the rise, foam uniformity, and freedom from splits.

True, a bench test cannot duplicate the varying production conditions encountered in plants all over the country. But it does assure you of constant uniformity in the significant surfactant properties. It has done much to help bring about widespread acceptance of the one-shot process where once there was hesitation.

For complete data, write Dept. JN-4002, Silicones Division, Union Carbide Corporation, 270 Park Ave., New York 17, N. Y. (*In Canada:* Union Carbide Canada Limited, Toronto 12.)

Unlocking the secrets of silicones

Rubber, Monomers, Resins, Oils and Emulsions

UNION CARBIDE **SILICONES**

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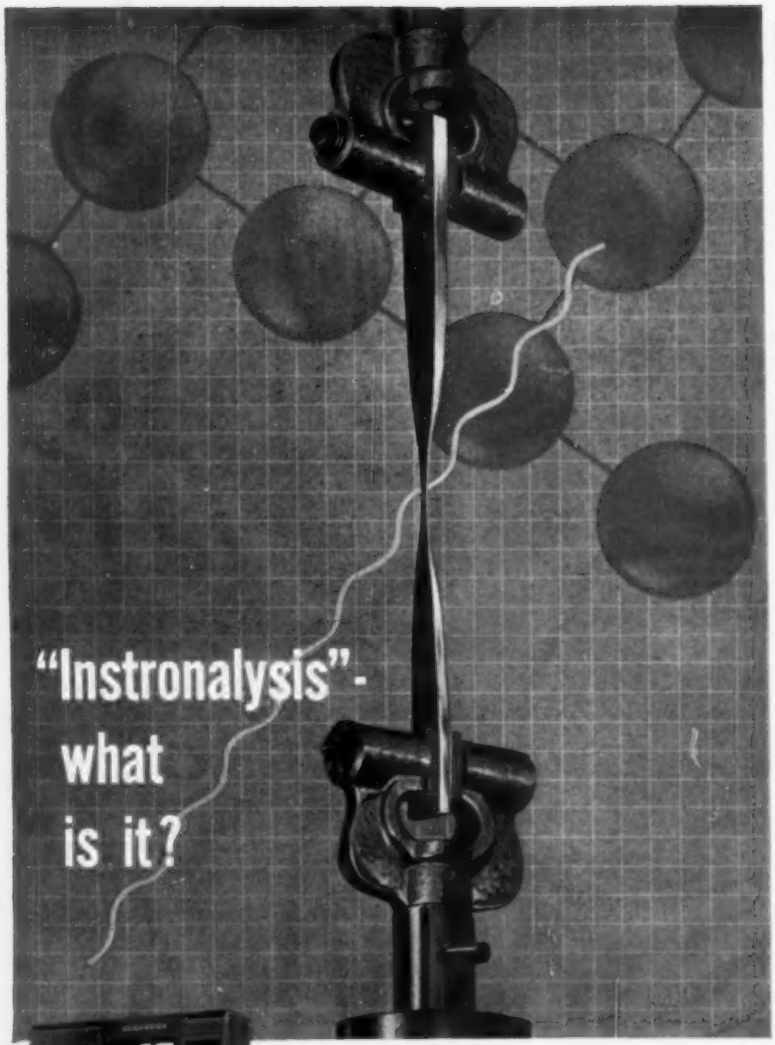

The Instron comes in various models and sizes, to suit the widest applications — for tests under all sorts of environmental conditions. ILLUSTRATED: **FLOOR MODEL**—load ranges from 2 grams to 10,000 lbs.

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A reinforced plastic circular bait tank holding 11 gallons of water is available from Zenith Plastics Co. Called Skipper's Scooper, that tank is 18 inches high and 17½ inches in diameter. A six volt-16 amp or 12-volt-eight amp DC motor operating a self-priming pump which provides a complete change of water every two minutes can be supplied.

Tank is carried inboard so it offers no drag or splash. Rounded edges eliminate injury to bait.

Readers' Service Item 51

Custom Instrument Cases

Hollywood Plastics, Inc., has formed a new division for the custom molding of instrument cases. The cases, of ABS thermoplastic, can be produced in any shape and with specially formed interior compartments to hold different instruments.

Readers' Service Item 52

Wire and Cable Strapping

A wire and cable tying system, reportedly offering ease of installation, low cost, and no waste, is available from Electrovert Inc. Designated Insuloid Strapping, the system consists of a PVC belt with mounting holes, and a stud-like insert. The strap is wrapped around the wire or cable and held by the stud.

Insuloid Strapping comes in 75-foot lengths, and in widths of 5/16 and ½ inches.

Readers' Service Item 53

DOW | RESINS

BRINE LOSES ITS BITE

When "reefer" hatch covers are preform moldings

Refrigerator car hatch covers take a beating from weather, hard use, and corrosive brine. Preform molded polyester hatch covers prove they can take it, and save money for the user, as well!

The Plastics Division of General American Transportation Corporation preform molds the durable hatch covers shown above for Standard Railway Equipment Manufacturing Company. The results are economical covers with excellent resistance to weathering and to the attack of salt; they won't warp or lose their strength and they last the life of the car with little or no maintenance.

Reinforced polyester moldings are low in cost, too. Nearly any configuration can be molded, greatly reducing the number of costly production operations normally required by other materials.

Preform moldings offer advantages in cost, in production ease, in long life under difficult service conditions; and the types of products for which they can be used are virtually unlimited. The Dow Chemical Company supplies the basic monomers for polyester resins for premix, preform and mat moldings—Dow styrene and Dow vinyltoluene.

For information on these Dow monomers, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1967DT10.

See "The Dow Hour of Great Mysteries" on NBC-TV

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Patent Digest

Materials

Thermosetting Aminoplast Resins Cured with Amino Acid Catalyst. No. 2,914,504. W. Metzger and H. Meis, Letmathe, Westphalia, Germany (to Rutgerswerke AG., Frankfurt, Germany).

Halogen-Containing Resins Stabilized with Organo-Tin Mercapto Compounds. No. 2,914,506. G. P. Mack, Jackson Heights, and E. Parker, New York, N. Y. (to Carlisle Chemical Works, Inc., Reading, O.).

Acrylic Resins Modified with Alkanolamines. No. 2,915,481. G. W. Ayers, Chicago, M. J. Geerts, Evanston, and W. A. Krewer, Crystal Lake, Ill. (to Pure Oil Co., Chicago, Ill.).

Depigmenting Polymeric Compositions with Amine Settling Aids. No. 2,915,482. F. B. Nagle, N. R. Ruffing, and P. W. Wright, Midland, B. A. Kozakiewicz, Bay City, and A. F. Roche, Freeland, Mich. (to Dow Chemical Co., Midland, Mich.).

Plasticized Perfluorochloroethylene Polymer and Process for Preparing Porous Articles Therefrom. No. 2,915,483. W. S. Barnhart, Cranford, N. J. (to Minnesota Mining and Manufacturing Co., St. Paul, Minn.).

Polyester Compositions, Water-Dispersible Polyester-Aminoplast Condensation Resins Made Therefrom, and Methods for Producing Them. No. 2,915,486. J. P. Shelley, Drexel Hill, Pa. (to Rohm & Haas Co., Philadelphia, Pa.).

Benzoic Acid-Modified Alkyd Resins and Their Production. No. 2,915,488. W. M. Kraft, Verona, and H. M. Metz, Fair Lawn, N. J. (to Heyden Newport Chemical Corp.).

Modified Acrolein-Pentaerythritol Reaction Products and Their Production. No. 2,915,498. W. M. Kraft, Verona, N. J. (to Heyden Newport Chemical Corp.).

Process for the Manufacture of Cast Resins or Urea-Formaldehyde and the Like, and Resins so Produced. No. 2,915,503. R. E. Vogel, Leutkirch, Allgau, Germany.

Polyvinyl Butyral. No. 2,915,504. F. Berardinelli, S. Orange, N. J. (to Celanese Corp. of America, New York, N. Y.).

Condensation Polymers of 4-Hydroxypiperidine. No. 2,915,505. F. H. Koontz and J. R. Schaefgen, Wilmington, Del. (to E. I. du Pont de Nemours & Co., Wilmington, Del.).

Trifluorochloroethylene Interpolymers. No. 2,915,506. F. J. Honn, Westfield, N. J. and J. M. Hoyt, Woodside, N. Y. (to Minnesota Mining and Manufacturing Co., St. Paul, Minn.).

Hydroxylated Polystyrenes. No. 2,915,511. J. A. Blanchette, E. Longmeadow, Mass. (to Monsanto Chemical Co., St. Louis, Mo.).

Aminated Polystyrenes. No. 2,915,512. J. A. Blanchette, E. Longmeadow, Mass. (to Monsanto Chemical Co., St. Louis, Mo.).

Dulled Article Consisting of a Polyamide and a Normal Metal Salt of a Saturated Aliphatic Dicarboxylic Acid. No. 2,919,258. E. W. Pietrusza, Morristown, and R. C. Wincklhofer, Whippany, N. J. (to Allied Chemical Corp.).

Light Stabilized Polyvinyl Chloride Compostions. No. 2,919,259. R. A. Naylor, Stamford, Conn. and W. B. Hardy, Bound Brook, N. J.

Polyvinyl Chloride Resin Compositions Comprising a Polyvinyl Chloride Resin, No. 2,920,055. W. E. Leistner and O. H. Knoepke, Brooklyn, N. Y. (to Argus Chemical Corp.).

Polyepoxide-Amine Compositions. No. 2,921,037. K. Andres, R. Wegler, and G. Frank, Leverkusen, Germany (to Farbenfabriken Bayer AG., Leverkusen, Germany).

Epoxide Resin Composition. No. 2,291,040. C. A. May, Oakland, Calif. (to Shell Development Co., Emeryville, Calif.).

Organic Plastics Containing N,N'-Dioleoyl Polyethylene Polyamines or Related Compounds. No. 2,921,048. A. Bell and C. E. Tholstrup, Kingsport, Tenn. (to Eastman Kodak Co., Rochester, N. Y.).

Printed copies of patents are available from the Commissioner of Patents, Washington 25, D. C. Prices, 25c each
—The Editor

Production of Polyurethane Foams Using Molybdenum Compounds as Catalysts. No. 2,916,464. H. Ebneth, Leverkusen, H. Schultheis, Koln-Stammheim, and H. Nordt, Leverkusen, Germany (to Mobay Chemical Co., Pittsburgh, Pa.).

Cross-Linked Plastics of High Molecular Weight and Process for Producing Same. No. 2,916,472. G. Nischk, Leverkusen, and H. Holtschmidt, Koln-Stammheim, Germany (to Fabrbenfabriken Bayer A.G. Leverkusen, Germany, and Mobay Chemical Co., Pittsburgh, Pa.).

Polymers of 3,4-Epoxycyclohexylmethyl 3,4-Epoxycyclohexanecarboxylates. No. 2,917,469. G. Phillips, Charleston, and F. C. Frostick, Jr., C. W. McGary, Jr. and C. T. Patrick, Jr., S. Charleston, W. Va. (to Union Carbide Corp.).

Polypoxide Compositions. Nos. 2,917,493, 2,918,444, and 2,921,925. B. Phillips Charleston, C. W. McGary, Jr., S. Charleston, and C. T. Patrick, Jr., St. Albans, W. Va. (to Union Carbide Corp.).

Copolymer of a Fluoro-Butadiene and an Acrylic Comonomer and Process of Making Same. No. 2,917,496. F. J. Honn, Westfield, N. J. (to Minnesota Mining and Manufacturing Co., St. Paul, Minn.).

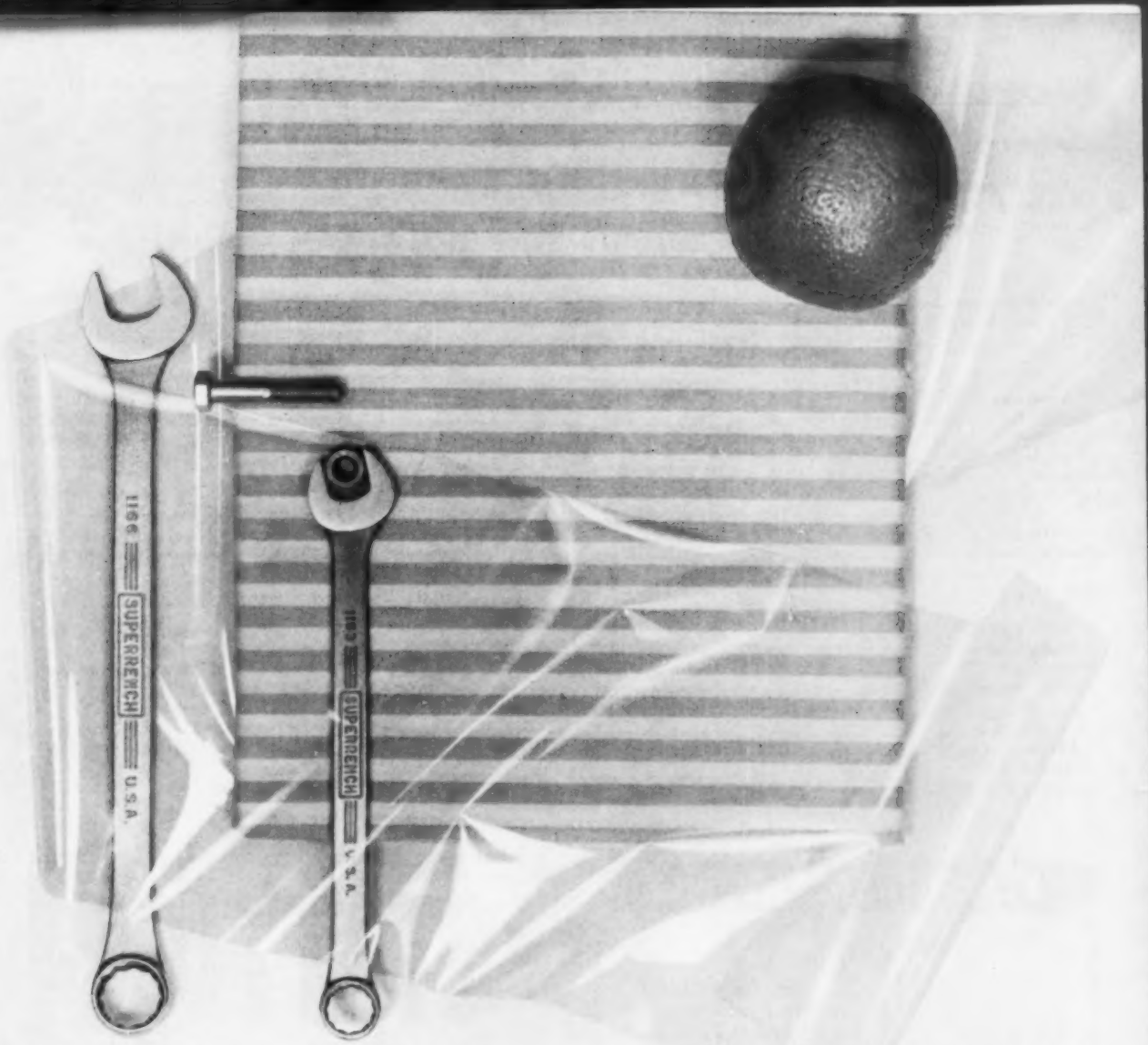
Bacteriostatic Plastic. No. 2,919,200. M. T. Dublin and J. S. White, University City, Mo. (to Steril-Plast, Inc., St. Louis, Mo.).

Polyethylene Telomre - Polyalkylene Oxide Block Copolymer and Method of Preparing Same. No. 2,921,920. J. J. Smith, Upper Montclair, and W. T. Reichle, Bloomfield, N. J. (to Union Carbide Corp.).

Epoxy Resin and Process of Making and Curing the Same. No. 2,921,049. H. L. Moroson, Elizabeth, N. J. (to Reichhold Chemicals, Inc., Detroit, Mich.).

Polyester Film and Process Therefor. No. 2,921,051. L. E. Amborski, Buffalo, E. F. Izard, Kenmore, and C. E. Sproog, Grand Island, N. Y. (to E. I. du Pont de Nemours & Co., Wilmington, Del.).

Polyesters of Sulfonyldibenzoic Acid and Gem-Dialkyl Glycols. No. 2,921,052. J. R. Caldwell and J. W. Wellman, Kingsport, Tenn. (to Eastman Kodak Co., Rochester, N. Y.).



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Patent Digest (Cont'd.)

Equipment

Rotary Molding Machine and Method of Molding. No. 2,912,339. E. W. Pitzer, Bartlesville, Okla. (to Phillips Petroleum Co.).

Molding Apparatus. No. 2,915,784. H. Z. Gora, Stratford, Conn. (to Eagle-Picher Co., Cincinnati, O.).

Apparatus Including Tube Flattening Rollers for Inflating Tubular Film. No. 2,916,764. K. G. Gerber, Welwyn Garden City, England (to Imperial Chemical Industries Ltd., London, England).

Method of and Appartus for Making Plastic Containers. No. 2,919,462. J. H. Friden, Maplewood, N. J. (to American Can Co., New York, N. Y.).

Manufacture of Hollow Articles from Plastics. No. 2,918,698. R. Hagen and N. Hagen, Siegburg, Rhineland, Germany.

Molding Method and Apparatus. No. 2,917,776. I. Dorman, Whitestone, and C. G. Hoos, Flushing, N. Y.

Pressing Tools Particularly for the Manufacture of Large-Area Pressings. No. 2,916,771. K. Lang, W. Barthel, W. Ladewig, F. Haus, W. Reichelt, E. Klauss, and A. Schadlich, Zwickau, Germany.

Plastic Injection Molding Machine. No. 2,916,770. L. J. Lemoine, Leominster, Mass.

Injection Moulding Machines. No. 2,916,769. K. H. Baigent, Surrey, England (to R. H. Windsor Ltd., Chessington, Surrey, England).

Locking Device for Injection Molding Machines. No. 2,916,768. H. K. Quere and B. J. Helders, Vaassen, Netherlands (to N. V. "Industrie" V. H. v. Lohuizen & Co., Vaassen, Netherlands).

Film Casting Apparatus Including Means to Restrain Transverse Shrinkage of the Film. No. 2,916,767. W. H. Stevens, Nashville, Tenn. (to E. I. du Pont de Nemours & Co., Wilmington, Del.).

Method and Apparatus for Making Blown Plastic Articles. No. 2,908,034. J. W. Hackett, Toledo, O. (to Owens-Illinois Glass Co.).

Plastic Molding Machine. No. 2,917,773 D. J. Burke, E. Cleveland, O. (to Erico Products, Inc., Cleveland, O.).

Apparatus for Producing Objects of Cured Plastic Material. No. 2,908,939. H. Amos, Burton, Wash. (to Pastushin Aviation Corp., Los Angeles, Calif.).

Method and Apparatus for Finishing Molded Articles. No. 2,908,936. K. B. Kilborn, Akron, O. (to Goodyear Tire & Rubber Co., Akron, O.).

Extrusion Apparatus. No. 2,908,938. C. W. Taylor, Akron, O. (to Goodyear Tire & Rubber Co., Akron, O.).

Plastics Winding Machine. No. 2,910,251. S. P. Prosen, Lanham, and H. B. McClelland, Jr., Rockville, Md. (to U. S. A.).

Apparatus for Vacuum Thermoforming. No. 2,190,728. A. G. Rowe, Jr., Wilmington, Del. (to E. I. du Pont de Nemours and Co., Wilmington, Del.).

Vacuum Molding Machine. No. 2,907,069. R. L. Butzko, Bridgeport, Conn. (to National Cleveland Corp., Cleveland, O.).

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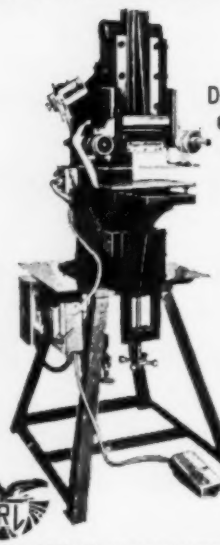

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A unique pigment for flame retardance in halogenated plastics and paints

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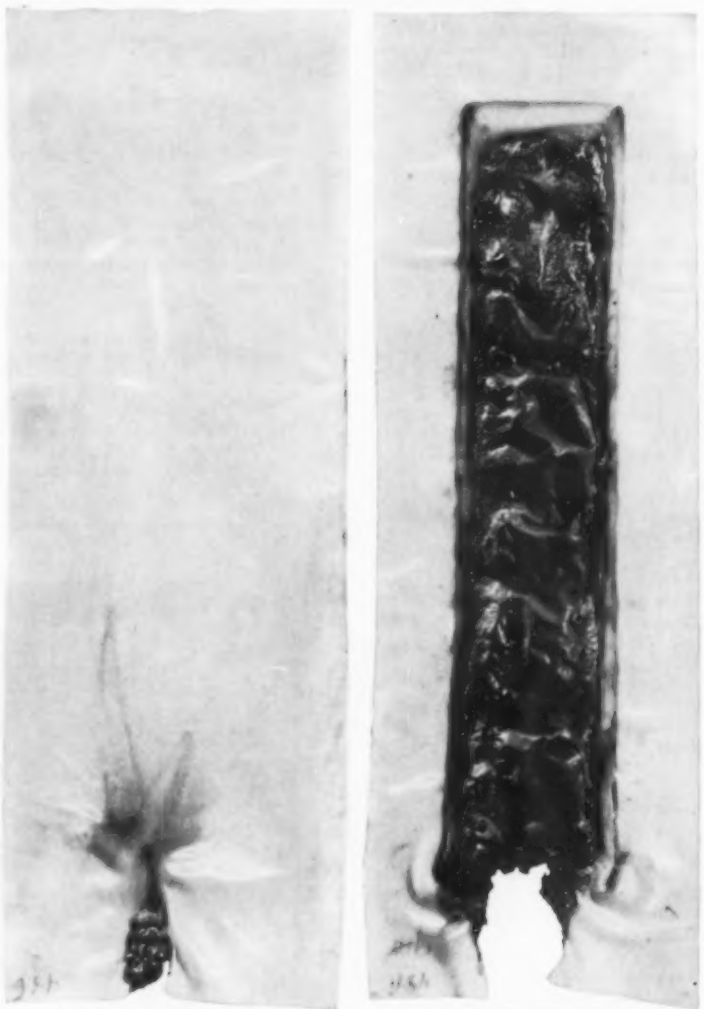
Here's a quick run-down on the outstanding features of this significant new ONCOR pigment:

1. **Effective Flame Retardance** – ONCOR 23A pigment compares favorably with conventional antimony oxides in flameproofing efficiency in halogen-containing resins for plastics and paints. In tests on vinyl films, ONCOR 23A pigment has given equivalent flame resistance compared to conventional antimony oxide, on an equal weight basis.
2. **Low Tinting Strength** – ONCOR 23A pigment has a low and uniform tinting strength. In vinyl film tests, tinting strength consistently measures between 60% and 65% of a conventional antimony oxide standard. This allows most effective use of colorants.
3. **Low Specific Gravity** – Because of its special physical structure, ONCOR 23A pigment has a lower specific gravity than regular antimony oxides. This means a higher volume yield per pound of pigment.
4. **Excellent Dispersion Characteristics**—as a result of careful production controls, ONCOR 23A pigment has a particularly uniform particle. This assures consistently good dispersion in both plastics and paints.

ONCOR 23A pigment is suggested for use in all halogenated plastic and paint compositions requiring flame resistance. It may be used with polyvinyl chloride, vinyl chloride copolymers, chlorinated paraffins, chlorinated rubber, chlorosulfonated polyethylene, chlorinated polyesters and the commercial fluoropolymers.

Additional information on the new ONCOR 23A pigment is provided in the National Lead Company Data Sheet just off the press. The handy coupon at the right will bring you a copy by return mail.



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Article Abstracts

Materials

"Low-Loss Laminates for High Temperature Electrical Structures," S. A. Miller, MATERIALS DESIGN ENG., 52, 2, 16 (Aug. 1960).

A new resin used in filament-wound or fabric-reinforced structures is shown to have good retention of electrical and mechanical properties at 500-600° F.

"Polymer Science: Simplicity and Sophistication," J. R. Whinfield, TRANS. PLASTICS INST., 28, 75, 86 (June 1960).

This is the introductory talk presented at the March 1960 Conference on "Polymeric Progress."

"Newer Methods of Polymerization," Geoffrey Gee, TRANS. PLASTICS INST., 28, 75, 89 (June 1960).

Recent polymerization methods are reviewed from the standpoint of controlling the polymer structure.

"A New Polymerization Technique with Ziegler Catalysts," G. Bier, A. Gumboldt, and G. Lehmann, TRANS. PLASTICS INST., 28, 75, 98 (June 1960).

Polymerization of olefins with special catalysts of the Ziegler type has led to kinetic results that differ from published data.

"High-Temperature-Resistant Materials," N. J. L. Megson, TRANS. PLASTICS INST., 28, 75, 125 (June 1960).

Special interest in materials resistant to high temperatures arose from the needs of fast-flying aircraft and rockets. While linear polymers are generally unsuitable because of their relatively-low softening temperatures, three-dimensional polymers offer more hope.

"Acetal Polymers," W. H. Linton, TRANS. PLASTICS INST., 28, 75, 131 (June 1960).

A discussion of the properties of Delrin acetal resin.

"Differential Thermal Analysis," C. B. Murphy, MODERN PLASTICS, 37, 12, 125 (Aug. 1960).

The applications of this technique to the study of the chemistry and properties of plastics are reviewed.

"Meeting All the Problems of Mechanized Extrusion Cutting," Benjamin Stevenson, PLASTICS INDUSTRY, 18, 8, 38 (Aug. 1960).

How Natvar Corp. uses a modified cutter to handle its cutting problems.

"Polyolefins," H. C. Raine, TRANS. PLASTICS INST., 28, 75, 153 (June 1960).

How the high-polymeric olefins picture has been changed by the discoveries of Ziegler and Natta.

"Polyesters of Carbonic Acid," H. Schnell, TRANS. PLASTICS INST., 28, 75, 143 (June 1960).

High molecular-weight polycarbonates are reviewed.

Equipment

"Fully Automatic Incorporation of Metal Parts," K. Wopalka, KUNSTSTOFFE, 50, 2, 142 (Feb. 1960).

A twin cavity injection mold, designed for injection machines with maximum capacities up to 15 grams, is furnished with a detachable device which inserts a brass wire into the mold. Two knives simultaneously cut the wire to uniform length. (In German).

"Continuous Forming of Thermoplastic Sheet by a Rotational Deep-Drawing Method," G. Missbach, KUNSTSTOFFE, 50, 2, 140 (Feb. 1960).

A revolving vacuum drum, over which specially-designed multicavity mold sleeves can be fitted, processes sheet directly from roll, extruder, or calender. (In German).

"Vapor Phase Chromatography in the Analysis of Solvents for Varnishes," F. Sadowski and H. Wagner, PLASTE U. KAUTSCHUK, 7, 2, 103 (Feb. 1960).

Description of a cheap, simple device permitting easy and rapid analysis of varnish solvents by vapor phase chromatography. (In German).

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"Plastics Machinery at the 1959 Dusseldorf Plastics Exhibition," KUNSTSTOFFE, 50, 2, 87 (Feb. 1960).

Types of plastics processing machinery exhibited at Dusseldorf. (In German).

"Injection Molding Machine Safety Circuitry," J. D. Sherman, WESTERN PLASTICS, 7, 8, 26 (Aug. 1960).

Description of the safety interlocks used on injection machines.

"Mold Making Industry Entering a Challenging Period Now," Robert Lilligren, WESTERN PLASTICS, 7, 8, 28 (Aug. 1960).

What the moldmaker, molder, manufacturer, and designer can do for molds.

"Automatic Injection Molding Tool with Stripper and Electromechanical Safety Guard," K. Muller, KUNSTSTOFFE, 50, 8, 476 (Aug. 1960).

A description of the subject tool.

Applications

"Non-Lubricated Bearings and Piston Rings of Tetrafluorethylene," R. B. Fehr, Jr., SPE J., 16, 8, 943 (Aug. 1960).

Sound engineering and performance data are given on these applications.

"Rubber-Impregnated Paper," G. A. Copland and D. W. Thornton, RUBBER & PLASTICS AGE, 41, 7, 823 (July 1960).

A brief review of materials and production methods for making these papers.

"Reinforced Plastics in Missiles and Rockets," J. J. Mobilia and D. V. Rosato, SPE J., 16, 8, 949 (Aug. 1960).

It is shown that different type materials can be developed to meet many environmental conditions.

"Is a Breakthrough for Plastics in Building Due in the Sixties," A. G. H. Dietz, PLASTICS IND., 18, 8, 15 (Aug. 1960).

A review of this problem gives a conditional "Yes" as the answer.

"An All-Hydrocarbon Thermosetting Resin for Electrical Insulation," H. Clark and R. G. Adams, MODERN PLASTICS, 37, 12, 132 (Aug. 1960).

Properties of a new thermosetting resin show it to possess considerable potential in the electrical field.

"Field Erection of Plastic Shelters," A. F. Gurdo, J. M. Schramp, J. E. McCormick, and G. J. Stabler, MODERN PLASTICS, 37, 12, 113 (Aug. 1960).

Discussion of factors in on-the-site field fabrication of rigid r-p shelters for housing personnel and/or electronic gear.

"Some Problems in the Use of Plastics in Cosmetics Packaging," P. P. Hopf, BRIT. PLASTICS, 33, 6, 248 (June 1960).

Some of the pitfalls which may arise from use of plastics packaging for certain chemicals and formulations. Tests are suggested to assess suitability with certain chemical components.

"Applications of Plastics Materials in the Continental Chemical Industry," A. G. Turner, BRIT. PLASTICS, 33, 6, 244 (June 1960).

Report of a recent study on Continental uses of plastics materials for chemical engineering applications.

"How to Buy a Reinforced Plastics Boat," Syd Nichols, CANAD. PLASTICS p. 51 (July 1960).

Check points for intelligent purchasing of the boats.

Requests for copies, reprints, or further information on any article abstracted in this department should be addressed to the publisher of the magazine where the article appeared. The publishers and their addresses are given below:

"Applied Plastics"
The Scientific Press, Ltd.
11 Gloucester Road
London, S.W. 7, England

"ASTM Bulletin"
American Society for Testing Materials
1916 Race St., Philadelphia 3, Pa.

"Australian Plastics"
Australian Trade Publications, Ltd.
243 Elizabeth Street, Suite 406,
Sydney, N.S.W., Australia

"British Plastics"
Iliffe & Sons, Ltd.
Dorset House, Stamford St.
London, S.E.I., England

"Canadian Plastics"
341 Church St., Toronto, Ont., Canada

"Chemical and Engineering News"
1155 Sixteenth St. N.W.
Washington 6, D.C.

"Gummi & Asbest"
A. W. Gentner-Verlag
Forsterstrasse 131, Postfach 688
Stuttgart, W. Germany

"Hule Mexicano y Plasticos"
Filomeno Mata 13-11, Mexico, D.F.

"Industrial and Engineering Chemistry"
1155 Sixteenth St. N.W.
Washington 6, D.C.

"Industries des Plastiques Modernes"
Les Publications Techniques Associees
40 Rue du Colisee, Paris 8e, France

"Jornal de Plasticos"
Av. Rio Branco, 211
Sao Paulo, Brazil

"Kunststoffe"
Carl Hanser Verlag
Leonard Eck Str. 7, Munich 27,
Germany

"Kunststoff-Rundschau"
Brunke Garrels, Verlagsbuchhandlung
Borgfelder Strasse 83, Hamburg 26,
Germany

"Kunststoff Zerater"
Kettenhofweg 111
Frankfurt A.M., Germany

"Materials in Design Engineering"
Reinhold Publishing Corp.
430 Park Ave., New York 22, N. Y.

"Materie Plastiche"
Via Farneti 8, Milan, Italy

"Matiéres Plastiques"
Galerie du Center, Bloc 3
Rue des Fripiers, Brussels, Belgium

"Mechanical Engineering"
American Society of Mechanical Engineers
29 W. 39th St., New York 18, N. Y.

"Modern Plastics"
575 Madison Ave., New York 22, N. Y.

"Oesterreichische Plastic-Rundschau"
Ployer & Co.
Aegidiengasse 5, Vienna 6, Austria

"Plaste und Kautschuk"
Veb Verlag Technik
12 Unter den Linden
Berlin N.W. 7, Germany

"Plastic"
Danish Technical Press
31 Vester Farimogsgade
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Kunststoffeninstituut T.N.O.
Julianalaan 134, Delft, The Netherlands

"Plastics"
Temple Press, Ltd.
Bowling Green Lane, London E.C.I.
England

"Plastics Age News"
Plastics Age Co., Ltd.
34 Higashi-Shimizu-machi
Minami-ku
Osaka, Japan

"Plastics Industry News"
Institute of Polymer Industry, Inc.
Mitsubishi-Maka- 6-1
Marunouchi, Chiyoda-ku
Tokyo, Japan

"Plastics World"
Cleworth Publishing Co., Inc.
1 River Road, Cos Cob, Conn.

"Plastiques Informations"
94 Rue Saint-Lazare
Paris 9e, France

"Plastverarbeiter"
Rudolf Zechner Verlag, G.m.b.H.
Speyer/Rhein, Germany

"Poliplasti"
E.T.A.S., Via Andrea Mantegna 6,
Milan, Italy

"Practical Plastics"
Box 4850
G.P.O. Sydney, Australia

"Progressive Plastics"
481 University Avenue
Toronto 2, Canada

"Revista de Plasticos"
Inst. "Alonso Barba"
Serrano 119, Madrid, Spain

"Rubber and Plastics Age"
Rubber and Technical Press, Ltd.
Tenterden, Kent, England

"SPE Journal"
65 Prospect St., Stamford, Conn.

"Spectator"
Published by New England Chapter
Society of Plastics Engineers, Inc.
Somers, Conn.

"Transactions of the Plastics Institute"
6 Mandeville Place, London W.I.
England

"Western Plastics"
Western Business Publications
274 Brannan Street
San Francisco 7, Calif.

Directory

1 time	$19.00 per inch
6 times	$18.00 per inch
12 times	$15.00 per inch

Two Reed Prentice Injection Molding Machines, Model 10D—12 oz. (1954) complete with instruments, controls, etc., for immediate removal. Both machines are in excellent condition and priced reasonably. Call, write or phone for appointment to see in operation, before removal.

John Krach
ROGERS PLASTIC CORP.
West Warren, Mass.
HEmlock 6-7744

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IMMEDIATE DELIVERY

1—EEMCO 175 ton 36" x 36" Downacting 60" Daylight 48" Stroke
1—EEMCO 250 ton 36" x 60" Downacting 48" Daylight 36" Stroke
1—EEMCO 350 ton 36" x 36" Upwardacting 24" Daylight 24" Stroke

All three units complete with self contained pumping units for speeds to 400 IPM—NEW—NEVER USED.

Box 54
PLASTICS TECHNOLOGY
630 Third Avenue, New York 17, N.Y.

FOR SALE

Ovens, Grinders, Powder Mixers, Injection Molding Machines 1 oz. to 60 ozs. never used and used, Two, Three, Four-Head Blow Molding Machines, Extruders, granulators and refrigeration systems.

Acme Machinery & Mfg. Co., Inc.
500 Saw Mill River Rd., Yonkers, N.Y. YOnkers 5-0900
102 Grove Street, Worcester, Mass. Pleasant 7-7747

WANTED TO BUY

Used injection molding machines, ovens, granulators. One machine or complete plant.

Acme Machinery & Mfg. Co., Inc.
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102 Grove Street, Worcester, Mass. PLeasant 7-7747

COMPLETE MOLDING PLANT

Compression Molding Presses, 250,200,150 & 100 tons capacity — all self-contained, electrically heated automatic cycle controls; Preform Presses, Tumbling Barrells etc. Excellent condition. Inspect under power.

Call — Wire — Write

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INgersoll 9-1416

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Classified Rates $10.00 per inch.

Established firm in Southwest going into laminating has opening for man with experience in printing and laminating on vinyl and other thermoplastic materials for platen press laminations.

BOX 52
PLASTICS TECHNOLOGY
630 Third Avenue New York 17, N.Y.

CALENDAR of COMING EVENTS

October 17-19
Technical Association of the Pulp and Paper Industry. Fifteenth Plastics-Paper Conference. Hotel Syracuse, N. Y.

October 17-19
International Congress, 1960, on the Technology of Plastics Processing. Royal Institute for the Tropics, Amsterdam, Holland.

October 19-26
International Plastics Exhibition macroPlastic 1960. Exhibition Grounds, Utrecht, Holland.

October 25-27
American Standards Association. Eleventh National Conference on Standards. Sheraton-Atlantic Hotel, New York, N. Y.

November 7
SPE Ontario Section RETEC. Automation in Injection and Compression Molding. King Edward Sheraton Hotel, Toronto, Ontario, Canada.

November 15-17
National Academy of Sciences-National Research Council. Building Research Institute. 1960 Fall Conferences. Shoreham Hotel, Washington, D. C.

November 18
SPE Newark Section RETEC. Blow Molding Comes of Age. Hotel Essex House, Newark, N. J.

November 22
Manufacturing Chemists' Association. Tenth Semi-Annual Meeting and Midyear Conference. Statler-Hilton Hotel, New York, N. Y.

November 27-December 2
ASME Winter Annual Meeting. Statler-Hilton Hotel, New York, N. Y.

November 30-December 2
U. S. Army Signal Research and Development Laboratory. Ninth Annual Symposium on Technical Progress in Communication Wires and Cables. Berkeley-Carteret Hotel, Asbury Park, N. J.

November 30-December 2
British Plastics Federation. International Reinforced Plastics Conference. Cafe Royal, London, England.

January 24-27
SPE Seventeenth ANTEC. Shoreham Hotel, Washington, D. C.

February 7-9
SPE Sixteenth Reinforced Plastics Division Conference. Edgewater Beach Hotel, Chicago, Ill.

February 26-March 1
American Institute of Chemical Engineers. Petrochemical and Refining Exposition. Municipal Auditorium, New Orleans, La.

March 21-30
American Chemical Society. 138th National Meeting. St. Louis, Mo.

April 20-21
SPI Eighteenth Annual Western Section Conference. Hotel del Coronado, Coronado, Calif.

Positions Open

Classified Rates $10.00 per inch.

Molds (Injection) For Sale

All in excellent condition, ready for molding housewares, containers and covers. Some are brand new (duplicate) some are discontinued items. Will fit 8 and 12 oz. machines. Priced to move.

ROGERS PLASTIC CORPORATION
West Warren, Mass., HEmlock 6-7744

PLASTIC DESIGN AND DEVELOPMENT

Challenging position available for experienced Design and Development Engineer. Plastic design background helpful; assistant to Director of Product Design and Development. Will be responsible for mechanical design and detailing of products; assembly manufacturing processes, and cost estimating.

Minimum of five years experience and demonstrative creativity.

This is an outstanding growth opportunity with an expanding manufacturer with an excellent benefit program. Personal interview will be arranged.

Send resume to:

Mr. Jack Bloch
Director of Design & Development
Lama Industries, Inc.
3000 W. Pafford Street,
Forth Worth, Texas

Wanted—PLASTICS TOOL ENGINEER

Expert in designing and supervising building of injection molds.

Permanent position, bright future for man who qualifies.

BRIER MANUFACTURING CO.
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FINISHING SUPERVISOR & PROCESS ENGINEER

Plastic manufacturing company in Western Michigan with outstanding reputation in the plastic field and demonstrated yearly growth has openings for two high-caliber finishing foremen and a finishing process engineer. Applicants should have experience in decorative finishing of plastics, involving vacuum metalizing, silk screening, painting, hot stamping and assembly. Foremen should have demonstrated supervisory ability. Earnings in excess of $7,000.00, liberal vacation policy and insurance program. Moving expenses paid. Excellent area in which to live, work, play and raise a family. Write to:

Michigan Plastic Products, Inc.
Robbins Road
Grand Haven, Michigan
Attention: Mr. Charles Maitzen

Domestic Production and Sales of Plastics and Resin Material, May and June, 1960

Following are the partly estimated and revised statistics for the domestic production and sale of plastics and resinous material during the months of May and June, 1960. Units listed are in pounds, dry basis unless otherwise specified. Data on alkyds and rosin modifications have not been included since their use is primarily limited to the protective coating industry.

	May, 1960		June, 1960	
	Production	Sales	Production	Sales
Cellulose Plastics:				
Cellulose acetate and mixed ester:				
Sheets, under 0.003 gage	1,615,973	1,689,227	1,771,799	1,851,411
Sheets, 0.003 gage and over	1,801,670	1,827,159	2,079,830	1,836,505
All other sheets, rods, and tubes (including other cellulose plastics)	749,267	819,887	790,871	896,530
Molding and extrusion materials (including other cellulose plastics)	7,493,625	7,139,776	8,054,864	8,068,194
Nitrocellulose sheets, rods, and tubes	244,630	126,461	——	118,539
TOTAL	11,905,165	11,602,510	12,697,364	12,771,179
Phenolic and Other Tar-Acid Resins:				
Molding materials	18,602,565	15,739,940	19,338,838	15,550,523
Bonding and adhesive resins for—				
Laminating (except plywood)	5,884,901	3,657,785	5,364,225	3,355,780
Coated and bonded abrasives	1,308,319	1,159,466	1,179,599	921,691
Friction materials (brake linings, clutch facings, and similar materials)	921,260	903,193	947,211	837,829
Thermal insulation (fiber glass, rock wool)	2,948,259	2,957,876	3,497,550	3,299,115
Plywood	3,922,898	3,225,195	4,086,043	3,259,616
All other bonding and adhesive uses	6,100,652	5,572,706	5,768,723	5,200,226
Protective-coating resins unmodified and modified except by rosin	2,598,724	1,886,159	2,010,432	1,859,803
Resins for all other uses	4,024,195	3,261,399	3,570,269	3,233,450
TOTAL	46,311,773	38,363,620	45,762,890	37,518,033
Urea and Melamine Resins:				
Textile-treating and textile-coating resins	2,931,725	2,498,456	2,900,471	2,415,451
Paper-treating and paper-coating resins	2,250,027	2,517,061	2,866,150	2,363,014
Bonding and adhesive resins for—				
Laminating	3,271,862	2,425,223	3,149,620	2,132,518
Plywood	7,784,322	7,615,912	7,272,186	6,804,446
All other bonding and adhesive uses	2,364,756	2,366,863	2,406,722	2,386,558
Protective-coating resins, straight and modified	3,167,180	2,394,202	3,312,756	2,372,119
Resins for all other uses, including molding	10,937,019	9,327,793	9,839,415	8,003,245
TOTAL	32,706,819	29,145,510	31,747,320	26,477,351
Styrene Resins:				
Molding and extrusion materials:				
Straight polystyrene	20,314,634	19,468,850	24,141,283	18,077,626
All other	32,009,773	27,120,311	29,844,686	25,866,258
Protective-coatings	6,043,945	5,919,786	6,024,096	5,128,502
Textile and paper treating and coating resins	6,159,309	4,254,960	5,133,911	4,949,411
All other uses	15,051,985	22,466,455	15,287,245	19,544,196
TOTAL	79,579,647	79,230,362	80,431,221	73,565,993
Vinyl and Vinyl Chloride Resins:				
Polyvinyl chloride and copolymer resins (50% or more PVC) for—				
Film (resin content)		7,610,140		8,868,955
Sheeting (resin content)		11,623,220		12,073,818
Molding and extrusion (resin content)		24,220,922		23,683,258
Flooring (resin content)		5,465,910		5,331,549
Protective coating (resin content)		13,103,280		12,488,646
All other uses (resin content)		3,448,927		3,846,035
All other vinyl resins for—				
Adhesives (resin content)		8,193,856		11,534,426
Protective coatings (resin content)		4,890,786		5,265,352
All other uses (resin content)		2,427,751		2,433,047
		10,126,569		9,278,457
TOTAL	97,877,099	91,111,361	93,687,738	94,803,543
Coumarone-Indene and Petroleum Polymer Resins	20,492,816	19,799,401	21,040,681	20,777,821
Polyester Resins:				
For reinforced plastics	13,514,593	11,681,053	11,696,251	10,703,404
For all other uses	1,844,842	1,738,512	2,164,982	2,155,699
TOTAL	15,359,435	13,419,565	13,861,233	12,859,103
Polyethylene Resins:				
For film and sheeting		27,175,201		30,621,990
Molding materials		13,308,988		12,638,692
Extrusion materials		13,207,279		14,344,420
For all other uses		40,837,095		39,473,223
TOTAL	120,158,679	94,528,563	102,263,535[1]	97,078,325[2]
Epoxy Resins:				
For protective coatings		1,828,825		2,180,755
For all other uses		2,752,941		2,851,675
TOTAL	5,873,996	4,581,766	5,398,270	5,032,430
Silicone Resins	500,694	375,063	439,208	366,944
Miscellaneous Synthetic Plastics and Resin Materials	23,863,764	21,334,494	25,476,690	22,727,739
GRAND TOTALS	454,629,877	403,492,215	432,806,150	403,678,461

[1] 16.0% produced by the low-pressure process.
[2] 15.4% produced by the low pressure process.

SOURCE: United States Tariff Commission, Chemical Division.

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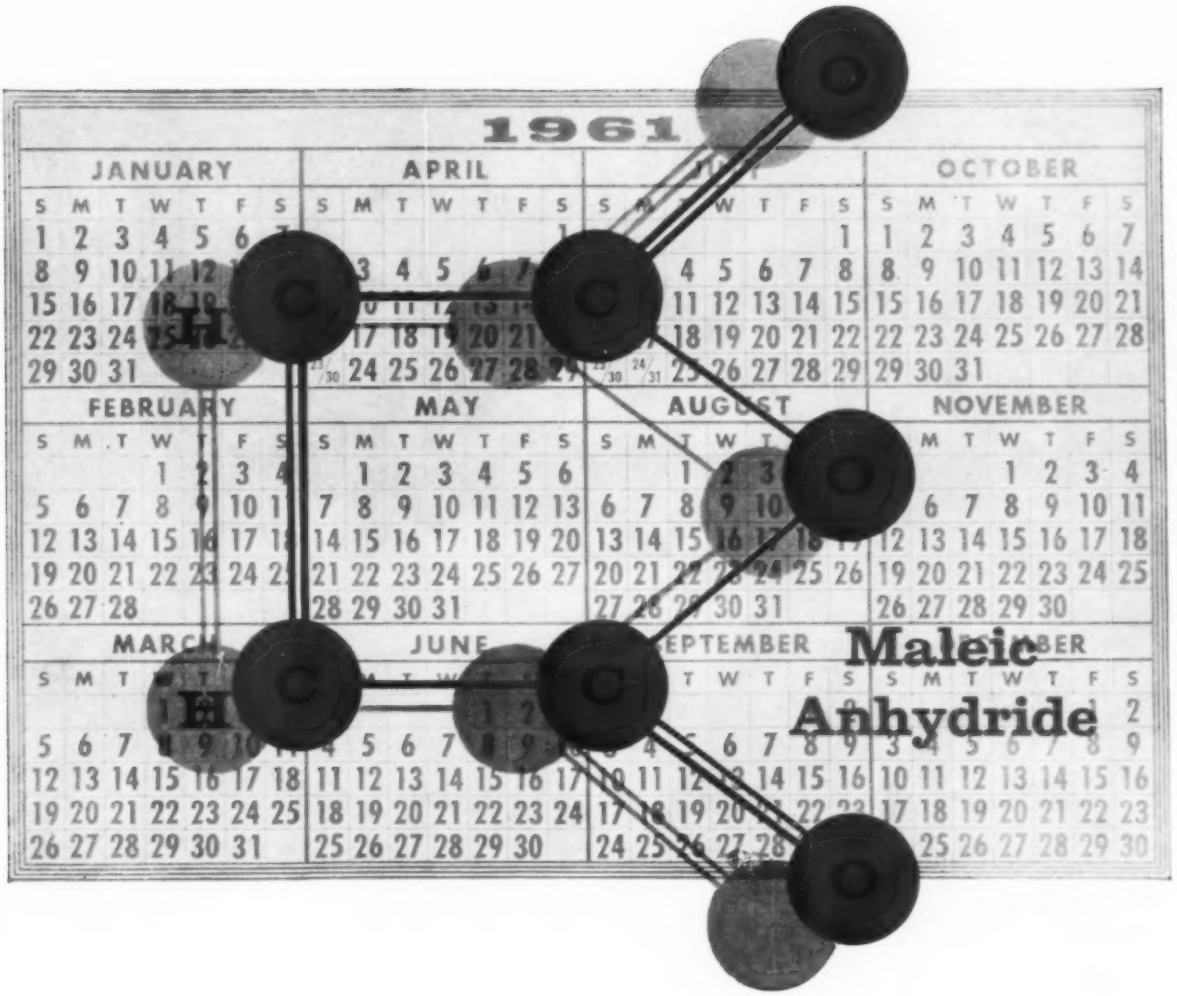

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